



Veterinary applications of thermography on cats and dogs

Introduction

How thermography works

Thermal, or infrared, energy is a part of the electromagnetic spectrum that is invisible because its wavelength is too long to be detected by the human eye (Figure 1); instead, we perceive it as heat. Unlike visible light, everything with a temperature above absolute zero emits heat. Even very cold objects, such as ice cubes, emit infrared radiation.

A thermal camera works similarly to a video camera, but instead of recording light, a thermal camera registers only infrared radiation (i.e., heat). This type of camera allows the temperature of an object to be measured and recorded, to create a thermal image – a thermogram. It makes no difference if it is too dark to see the object with the naked eye: the thermal image will be unaffected.

The higher the temperature of an object, the greater the amount of infrared radiation it emits. A thermal camera can thus not only record an infrared image but also measure the surface temperature of an object. An on-board processor performs image enhancement and calculations to measure the temperature of the surface of the object. This method of creating an image of an object while at the same time measuring its temperature has a number of novel applications within veterinary science.

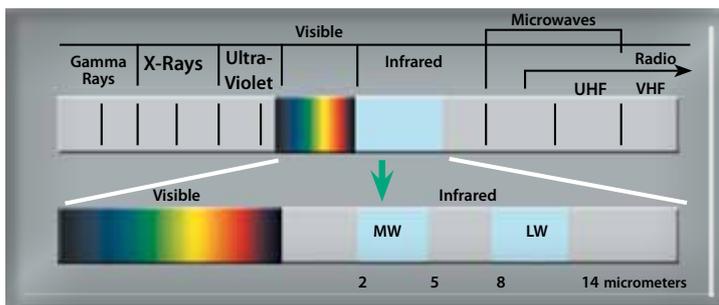


Figure 1. The electromagnetic spectrum, showing the infrared region.

Thermography: a method for noninvasive examination

Thermal cameras are small and easy to use.

An important concept is the “color palette.” A color palette is the set of colors that is used in a thermal image, with the specific colors varying with temperature. For example, a palette may display the coldest areas in blue and the hottest areas in white, with red and yellow in between.

Thermal cameras allow a wide choice of color palettes. It is important to select a palette that is easy to interpret when examining animals: for example, ‘high rainbow’ has easily distinguishable colors (Figure 2).

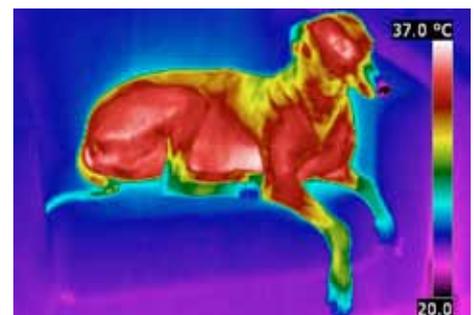


Figure 2.a. A thermogram of a greyhound on a sofa, displayed using color palette high rainbow



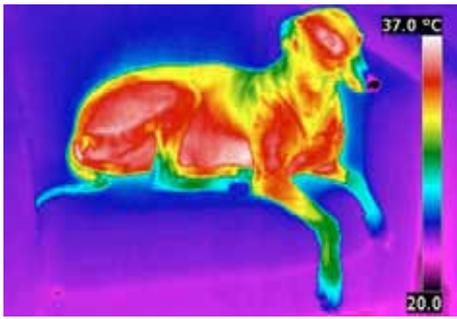


Figure 2.b. A thermogram of a greyhound on a sofa, displayed using color palette rainbow



Figure 2.c. A thermogram of a greyhound on a sofa, displayed using color palette medical

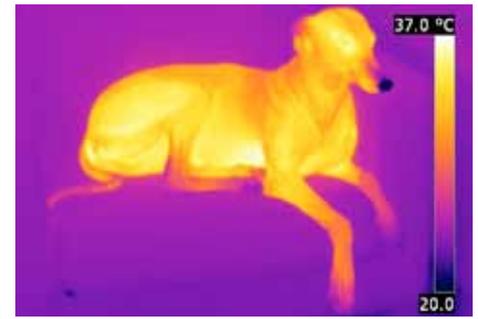


Figure 2.d. A thermogram of a greyhound on a sofa, displayed using color palette high iron

Thorough examination of an animal using thermography consists of taking thermograms that cover all parts of the body (Figures 3–7). The number of images depends on the size of the patient, with large animals requiring more. It is also useful to obtain thermal images of the paw prints of every patient (Figure 8): however,

this is not always possible – animals suffering significant pain will change their weight bearing, and an affected limb may leave virtually no paw prints.

Images are interpreted with the software provided with the thermal camera (e.g., FLIR QuickReport). Preliminary interpretation is

sometimes possible from the camera screen. The emissivity of animals with different types of fur has not yet been researched, so absolute temperature measurement is not currently possible. However, comparisons can be made: for example, comparing the left side with the right side. Paw prints can indicate asymmetries in weight bearing or possible infection/inflammation in the warmer paw, and can help interpretation of other images. The temperature difference between areas of interest is usually about 1°C if the change is clinically important (Figure 9).

Lastly, it is important to remember that clinical examination is also required with any diagnostic method.

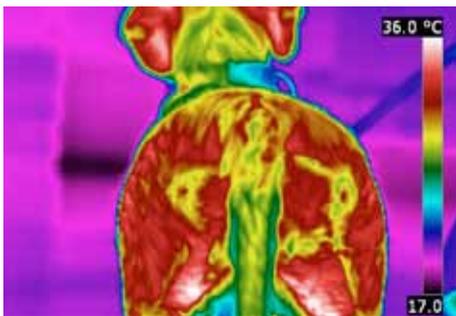


Figure 3. Examining an animal using thermography: from behind.

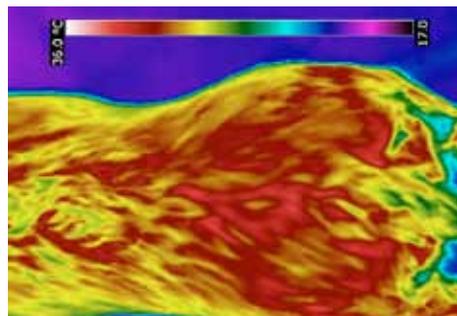


Figure 4. Examining an animal using thermography: from above.

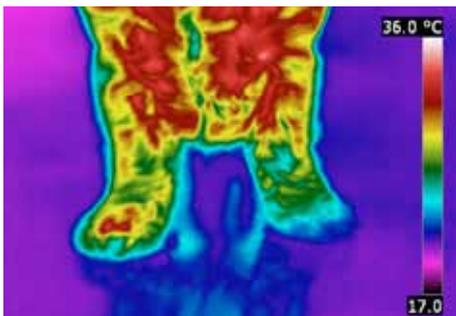


Figure 5. Examining an animal using thermography: from the front.

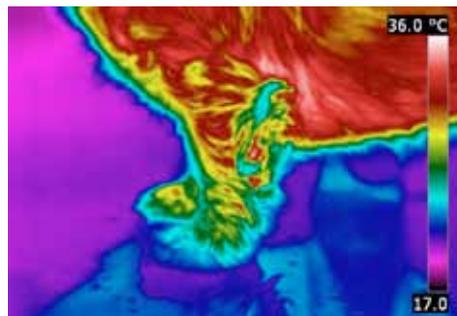


Figure 6. Examining an animal using thermography: from the left side.

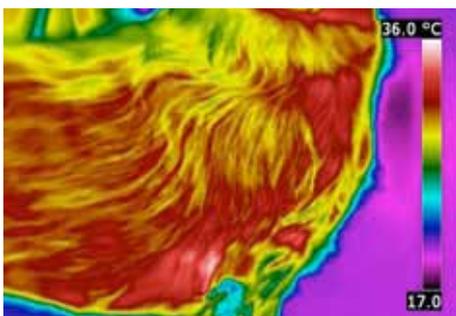
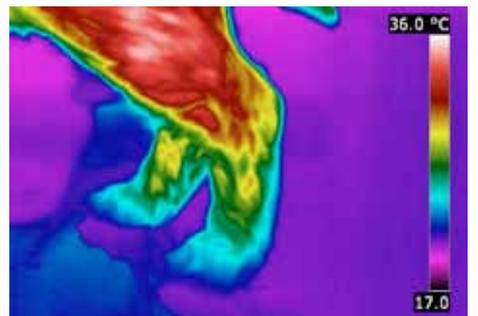


Figure 7. Examining an animal using thermography: from the right side.

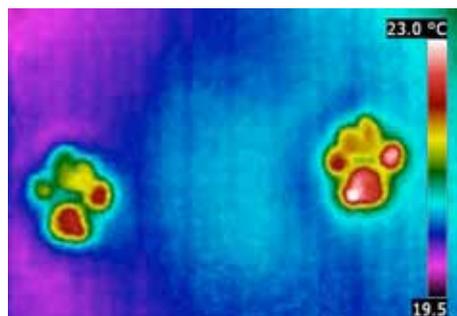


Figure 8. Examining an animal using thermography: paw prints. The (a) hind legs and (b) front legs.

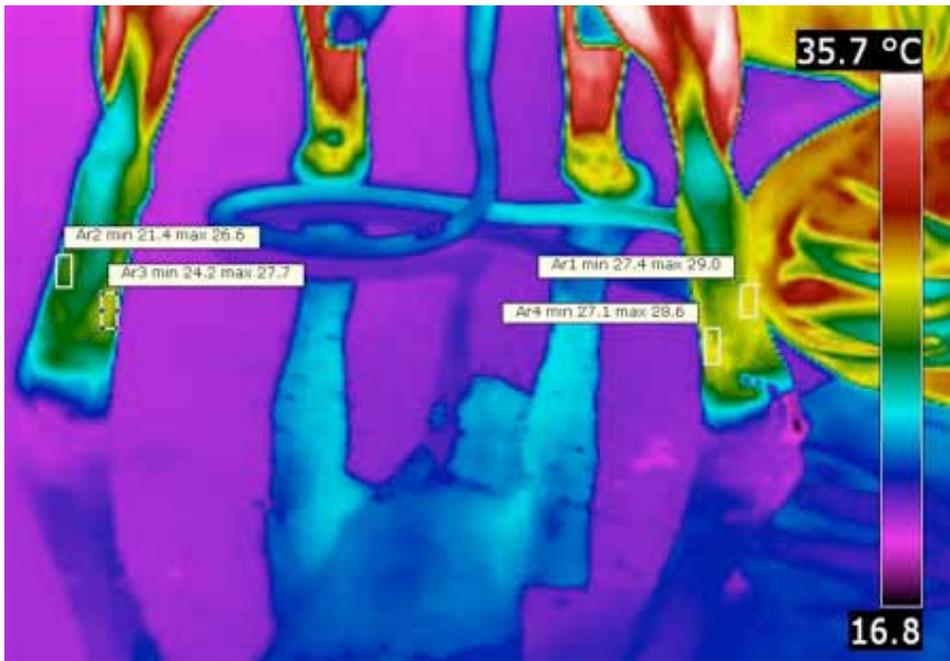


Figure 9. Clinically significant temperature difference between the tarsus area in the hind legs (lame dog).

Possible applications

Thermography can detect many things that change the normal thermal pattern, as it can show differences in thermal symmetry and abnormally warm or cold areas in patients. If the thermal pattern is not symmetrical or there are unexpected thermal anomalies, this may indicate, for example, infection, a soft tissue (tendon, muscle, etc.) problem, a joint problem, nervous dysfunction, or even a viper bite. Looking at this list of examples, it can be seen that thermography is particularly useful in pain localization, pain management, and follow-up for patients with these types of problems.

Patients that are presented for thermography usually have some kind of musculoskeletal problem – either the specific localization cannot be found or the patient is in follow-up for rehabilitation. Patients that have clear pain with an unknown localization are typical.

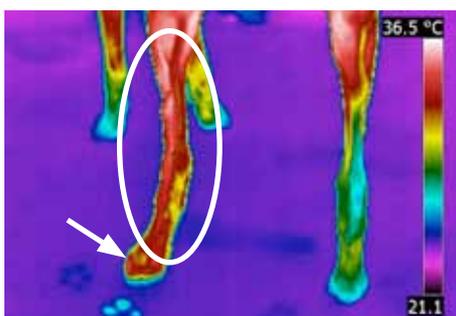


Figure 10. The abrasion (arrow) and the infected area (circle).

The following examples illustrate what can be accomplished with thermography.

Infection

The definition of infection is an inflammation process with, for example, a bacterium or virus causing the inflammation. Inflammation and infection cause an exothermic reaction: in other words, the infected part of the body is warmer than the surrounding tissues. Thermography can detect the inflammation process, whereas the naked eye cannot.

A 5-year-old greyhound (female) was limping slightly on her left hind leg, but only a small abrasion in one of the toes was found. Thermography showed that the problem involved a larger area (Figure 10). After examination of the thermograms, the treatment plan was changed from local treatment to systemic medication (nonsteroidal anti-inflammatory drugs (NSAIDs) and antibiotics).



Figure 11. Local infection (arrow) and the healed infection area (circle).

The dog responded well to the medication, and the lameness reduced immediately. Follow-up thermograms (Figure 11) taken the next day revealed that the infection was healing quickly and was only local.

The thermograms in this case show that thermography is a good tool for detecting injuries and planning proper medication for patients. Also, follow-up is easy and effective with thermography.

Inflammation

Inflammation can be determined by the response of the body to possible harm. The signs of inflammation include warmth, redness, swelling, pain, and loss of function. Inflammation does not involve bacteria or viruses. As the inflamed region is hotter than the surrounding area, thermography can detect this indication of inflammation.

A German shepherd was presented for thermography after two inconclusive orthopedic examinations. The lameness was fairly mild, but the owner of the dog was concerned, particularly because the orthopedic surgeon did not find anything specific, and the animal was still not functioning normally. An abnormally warm left right paw sole was seen on thermography (Figure 12). The owner later found and removed a small splinter from the paw, after which the symptoms disappeared. This diagnosis of localized inflammation would not have been possible without thermography.

Intramuscular injections can cause local inflammation. Thermography shows this especially clearly in poikilothermic animals (Figure 13a and 13b).

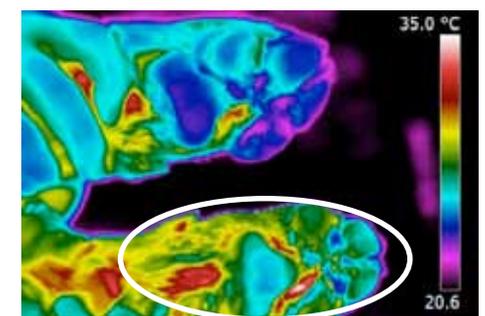


Figure 12. A warm left front paw sole (circle).

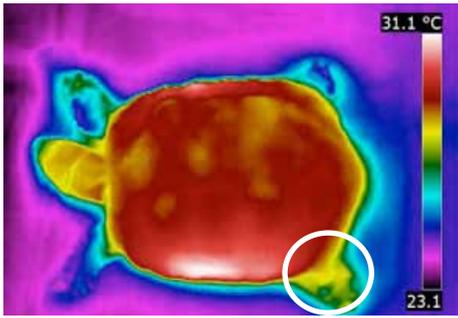


Figure 13. Localized inflammation after an intramuscular injection: a turtle from (a) above and (b) behind (circle).

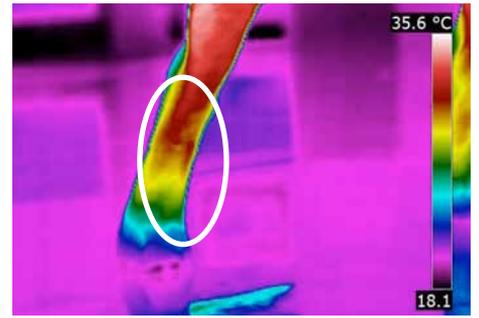
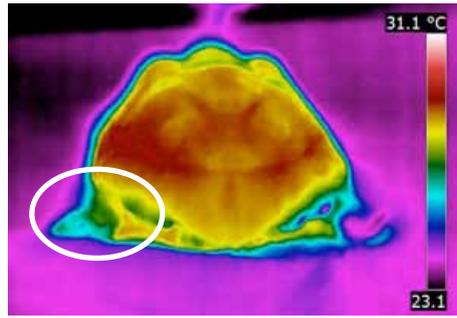


Figure 14. The right hind leg from the front. A slightly warmer area is seen here in the cranial aspect than in the left hind leg (Figure 15).

Tendons

Tendons usually appear colder than other structures in thermal images. Small injuries can be seen with thermography before any anatomical changes have occurred – after anatomical changes, injuries can be observed with ultrasonography or radiography.

A 4-year-old castrated male Staffordshire bull terrier was presented after ongoing slight right hind limb lameness. The symptoms included occasional unevenness of walk with the patient not putting any weight on the leg. The dog was examined by neurologists and an orthopedic surgeon, but nothing specific was found on clinical examination, radiography, or

magnetic resonance imaging (MRI). A lumbosacral problem was suspected but never confirmed.

After taking thermograms, abnormalities were seen in the plantar area of the right hind leg (Figures 14–15).

Joints

Different joint problems cause distinct types of functional problems for the animal and different types of pain.

Osteoarthritis is painful when active. After the acute phase, the animal might not feel much pain, but the disease may affect the use of muscles. Osteoarthritis can also be the consequence of another disease/process in the joint.

A young adult female working (herding) border collie presented with undulating pain and lameness in the right front leg. Previously, she had been diagnosed with osteochondrosis dissecans in the right elbow, and the joint was operated on. The operation is often curable, or at least allows the dog to function normally.

No specific cause of the lameness could be found through the usual examinations, and

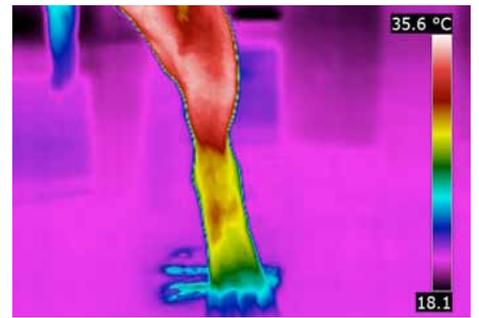


Figure 15. The left hind leg (normal temperature).

the owner wanted a second opinion and a thermographic examination. An obvious thermal difference was found in the right leg elbow area (Figure 16). Radiographs taken and evaluated by an orthopedic surgeon showed osteoarthritic changes. Herding with this dog must be limited.

Nonacute osteoarthritic processes can also be seen with thermography. A rottweiler had osteoarthritis in the left shoulder and was being treated with NSAIDs and acupuncture. Thermography was used to visualize the problems (Figures 17 and 18).

Nervous system problems

Nervous system problems are seen as cold areas where the nerve in question innervates the tissues. Nerve dysfunction

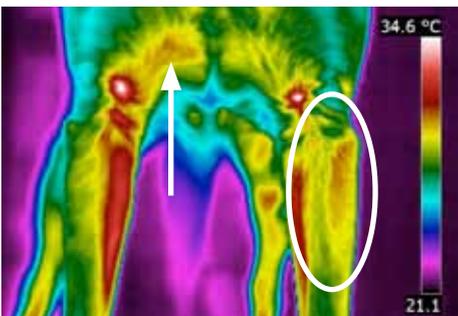


Figure 16. A warmer area in the left elbow area (circle) due to the arthritic process. The warmer area in the pectoral muscle is due to excessive use of the right front leg (arrow).

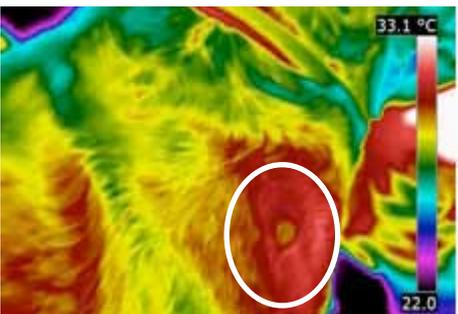


Figure 17. Osteoarthritis in the left shoulder caused this dog to use the right side more, and hence the area is warmer (circle).

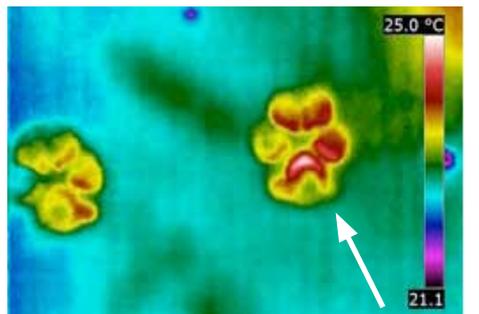
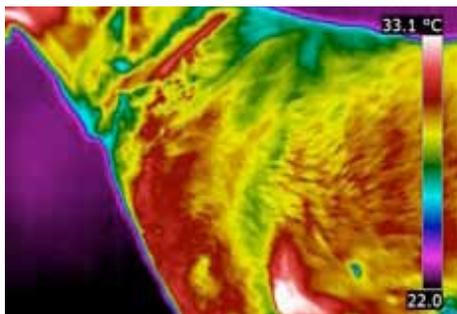


Figure 18. The paw prints are also slightly uneven due to pain, but the right front leg bears more weight than the left one (arrow).

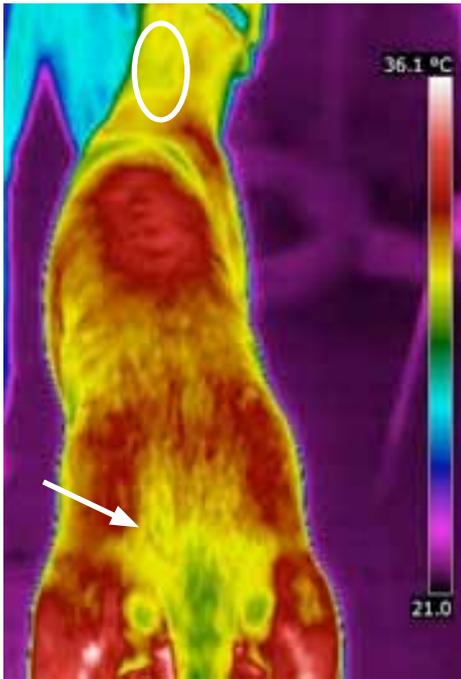


Figure 19. Cold areas in the neck area (circle) and a cold spot in the pelvic area (arrow).

can be due to trauma, compression, or a degenerative process. When the nerve does not work properly, the innervated areas (muscles, etc.) are not as active as usual, so the area is seen as colder than surrounding tissue in thermograms.

A male greyhound was presented because of continuous problems and pain. The owner did not want large-scale examinations but felt comfortable with thermography. Previously, calcification of the cervical vertebrae had been diagnosed, and the dog had had a rock lodged in one foot pad. The dog was limping on both front legs, and the left hind leg was shaking.

Thermography indicated that the previous nerve problem is still ongoing (Figure 19). Nerve problems in the neck area could also explain the lameness in the front legs. A cold spot in the pelvic area could explain the shaky left hind leg.

A pain clinic veterinarian found the cause of the shaking left hind leg to be sciatic nerve entrapment. Thermograms showed a colder area that correlated anatomically to the sciatic nerve area (Figure 20).

After acupuncture treatment, the affected area showed some improvement (Figure

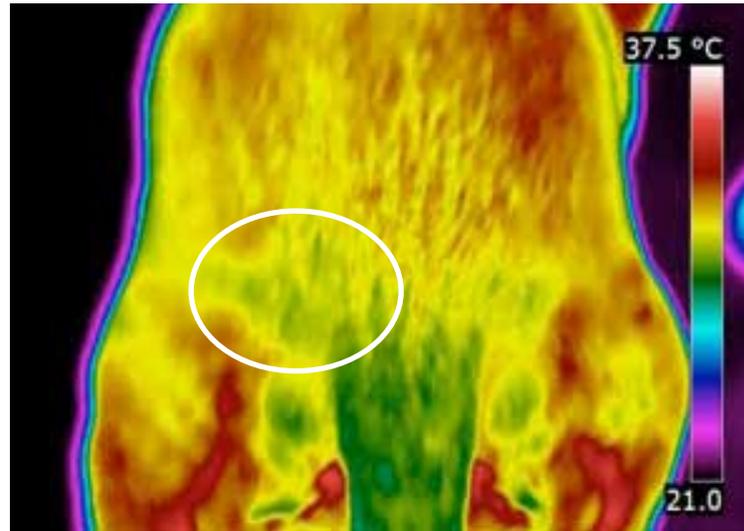


Figure 20. The sciatic nerve area is colder on the left side (circle).

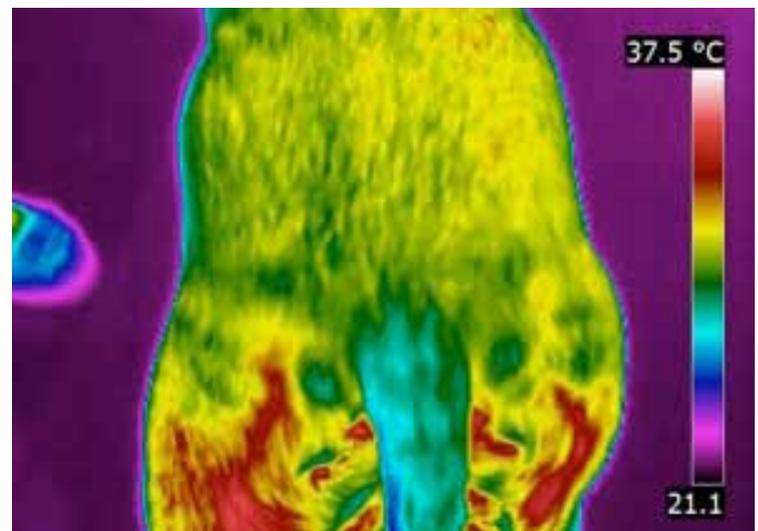


Figure 21. The left and right sides of the animal are more even in temperature after treatment.

21). Although the whole lumbar area is colder, it is also more even in temperature. The lower overall temperature could indicate improvement, mainly through reduced inflammation in the area due to the absence of pain and abnormal muscle usage.

Pain management with acupuncture and pain medication is ongoing in this dog since the problem can only be alleviated, not cured.

Pain localization/management

Thermography can be very useful in detecting pain. Cats are a good example since they do not show pain easily. Pain can be seen using thermography as warmer areas or areas of uneven temperature in

the animal. This warmth could indicate inflammation or infection, or be caused by excess use of the less painful limb.

A 5-year-old castrated male Bengal cat was presented due to aggressive behavior. The thermograms showed that one area around hip was much warmer than the other (Figure 22a). This was also seen in thermograms of the paw prints (Figure 22b).

After pain medication (NSAIDs), the behavior of the cat changed, and follow-up thermograms taken the next day showed a marked improvement, indicating lack of pain (Figure 23).

Radiographs of the hips and lumbar area were taken, and no findings indicating osteoarthritis were found. The conclusion

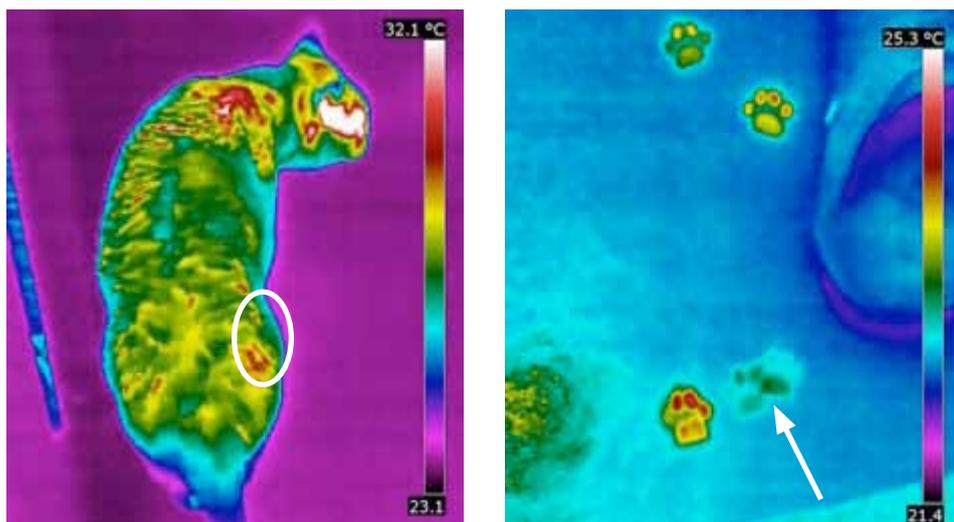


Figure 22. (a) A warmer right hind leg area due to pain (circle) and (b) paw prints showing no weight bearing by that leg (arrow).

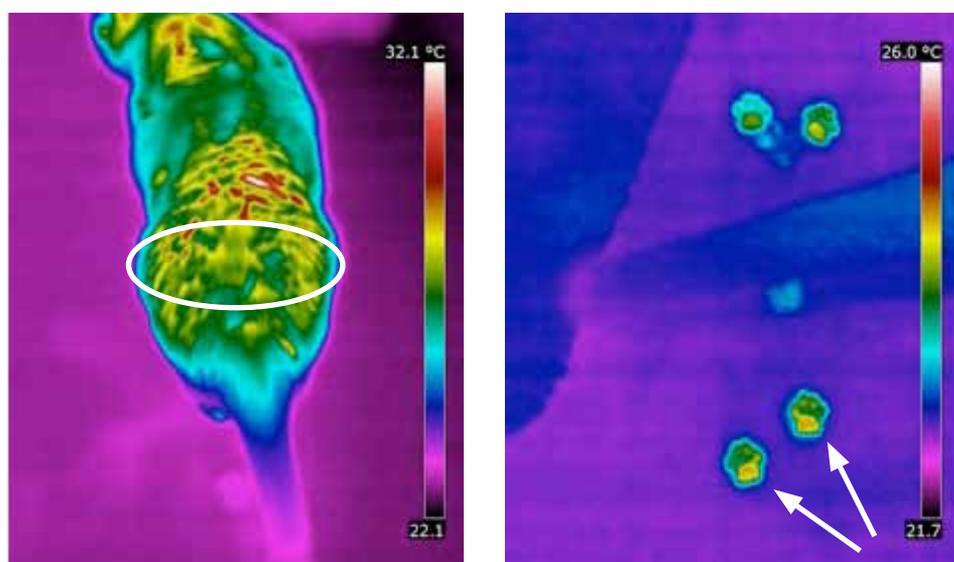


Figure 23. (a) No heat difference between the hip joint areas (circle) and (b) more even weight bearing (arrows).

was that the pain was due to muscle damage or joint luxation. Early stage osteoarthritis cannot be ruled out since the initial changes are not usually visible with radiography.

This cat will be monitored frequently by thermography so that any pain that develops can be treated as early as possible.

Final comments

As with any method of examination, there are aspects to the use of thermography that it is necessary to be aware of in order to avoid misdiagnosis. If the patient is wet (e.g., from rain), the moisture in the fur will affect the appearance of thermal images. Windy locations are not suitable

for thermography because heat escapes via evaporation, radiation, and conduction. Places where there is direct sunlight or other heat sources should also be avoided.

As a physiological diagnostic tool, thermography makes it possible 'to see the unseen' before anatomical changes have developed. The usefulness of thermal imaging comes into its own when there is a suspected tendon or muscle injury that is not yet visible (no anatomical changes) with anatomical diagnostic tools (e.g., radiography, ultrasound, CT, MRI), early diagnosis allowing the correct course of treatment to be started before the injury worsens.

One of the many positive aspects of thermography is that it does not radiate

and does not cause any harm to the animal (or its owner). Also, the animal can be fully awake during the procedure, and very sick and scared animals can have a stress-free experience since they are not handled during thermography.

Courses on small animal thermography are being developed by Mari Vainionpää at the University of Helsinki to meet the needs of clinicians interested in using this unique tool for diagnosis and follow-up.

Those using thermography to examine animals need to familiarize themselves with the techniques of thermography, especially the interpretation of thermal images, before making decisions about the treatment of patients or further procedures. First, knowledge of the physiology and anatomy of the animal in question is needed – the person doing the examination should be a veterinarian, or the findings discussed with one.



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