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Thermographic imaging in the diagnosis of equine sinonasal disease

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Summary

Twenty horses with sinonasal disease were referred to the reporting clinic. All horses were subjected to a clinical examination, examination of the oral cavity, endoscopic examination of the upper respiratory tract and a radiographic examination. In 9 horses computed tomography of the head was performed. A standardised thermographic examination was performed in all patients. An infrared camera was placed at a distance of approximately 1,5 meters in front and at both sides of the horse's heads. Surface temperatures in a defined area of interest (AOI) overlying the right and left maxillary sinuses were depicted. Mean temperatures in the AOI s were calculated and temperature differences (ΔT) were compared to the results of the contralateral sides. Correlation of thermographic results with clinical, endoscopic and radiographic findings was calculated statistically. No significant correlation between thermographic and clinical findings or the final diagnosis could be observed. In conclusion the diagnostic value of thermography in horses with sinonasal disease is regarded as limited.

Keywords: Diagnostik imaging, thermography, diagnosis, sinus, sinusitis

Thermographie in der Diagnostik von Nebenhöhlenerkrankungen beim Pferd

Ziel der Studie war die Untersuchung des diagnostischen Werts der Thermographie bei Pferden mit Nebenhöhlenerkrankungen. 20 Pferde mit Sinusitis (7 Stuten, 12 Wallache, 1 Hengst) zwischen 3 und 23 Jahren wurde untersucht. Die erkrankten Pferde entstammten den Rassen Traber (n = 14), Quarter horse (n = 3), Englisches Vollblut (n = 2) und einem Pony. Die Pferde wurde wegen einseitigem (n= 18) oder beidseitigem (n = 1) eitrigem Nasenausfluss sowie wegen einer Oberkieferfistel (n = 1) vorgestellt. Die Pferde wurden einer klinischen Untersuchung, einer vollständigen Untersuchung der Maulhöhle inklusive endoskopischer Untersuchung, einer Endoskopie der oberen Atemwege sowie einer radiologischen Untersuchung der Nasennebenhöhlen und der Oberkieferbackenzähne unterzogen. Bei 9 Pferden wurde zusätzlich eine computertomographische Untersuchung des Kopfes in Vollnarkose durchgeführt. Weiters wurde an allen Pferden eine thermographische Untersuchung unter standardisierten Bedingungen durchgeführt. Diese fand bei allen Patienten im selben Raum statt. Die Thermographiekamera wurde im Abstand von circa 1,5 m vor den Pferden und zu beiden Seiten positioniert. Die Halfter wurden einige Minuten vor den Untersuchungen entfernt und die Pferde in unsediertem, ruhigem Zustand untersucht. Für die weiteren Auswertungen wurden Regionen über den Kieferhöhlen (AOI's) definiert und die Temperaturgradienten sowie die mittlere Temperatur innerhalb der AOI's bestimmt. Diese Ergebnisse (ΔT) wurden mit den Werten der kontralateralen Seite verglichen. Anschließend wurden die Korrelationen der thermographischen Ergebnisse mit den Untersuchungsergebnissen der klinischen, endoskopischen und radiologischen Untersuchungen sowie mit den Abschlussdiagnosen statistisch (Spearman-Rho-Test) ermittelt.Vier der untersuchten Pferde waren an primärer Sinusitis erkrankt, 11 Tiere litten an sekundärer (dentaler) Sinusitis, bei 2 Patienten wurden Sinuszysten diagnostiziert. Weiters wurden die Diagnosen Sinusitis nach Kopftrauma und Siebbeinhämatom bei je einem Pferd gestellt. Bei 2 Patienten konnte die Ätiologie der Sinusitis nicht geklärt werden. Bei 10 von 20 Pferden konnte kein signifikanter Temperaturunterschied zwischen den linken und rechten AOI's festgestellt werden, bei weiteren 10 Pferden wurden signifikant höhere Temperaturen über den erkrankten Sinusarealen ermittelt. Bei einem Tier war die erkrankte Seite kühler als die gesunde, kontralaterale Seite. Die statistische Untersuchung ergab keinen signifikanten Zusammenhang zwischen den Symptomen oder der Abschlussdiagnose. Zusammenfassend muss der diagnostische Wert sowie die klinische Relevanz der Thermographie als diagnostisches Hilfsmittel bei Pferden mit Erkrankungen der Nasennebenhöhlen als begrenzt angegeben werden.

Schlüsselwörter: Bildgebende Diagnostik, Thermographie, Diagnostik, Sinus, Nebenhöhlenerkrankung

Introduction

Paranasal sinus affections are frequently diagnosed conditions in equines. Prior to the initiation of any treatment it is important to clarify, whether the sinusitis is of primary (i.e. in the course of an airway inflammation) or secondary origin. Secondary (dental) sinusitis is most frequently caused by apical infections of the caudal maxillary cheek teeth (Tridadan 108/208 through 111/211). Sinonasal disease might also result from facial trauma, the presence of sinus cysts, progressive ethmoidal haematoma (PEH), mycotic infections or sinonasal neoplasia (*Tremaine* and *Dixon* 2001, *Freeman* 2003). The most common clinical finding is unilateral purulent nasal discharge but unspecific symptoms like fever, reduced appetite, quidding and poor body condition might also be presenting symptoms. Based on clinical findings it is nearly impossible to make a definitive diagnosis concerning the aetiology of the sinonasal disease.

Radiography is currently the imaging technique most frequently used for the diagnosis of sinonasal disorders (*Gibbs* and *Lane* 1987, *Lane* et al. 1987 a and b, *Bertone* et al. 1993). In recent years the implementation of computed tomography (CT) has significantly contributed to the differentiation between primary and secondary (dental) sinusitis (*Henninger* et al. 2003).

Thermography has been described as a diagnostic technique for the diagnosis of orthopaedic problems (*Turner* 1991, 2001) and problems of the thoracolumbar region (Tunley and

Henson 2004) in veterinary medicine. However, the diagnostic potential of thermography has not yet been examined for the diagnosis of sinonasal disorders in horses. The aim of the present study was to evaluate the diagnostic potential and limitations of thermography in equine paranasal disease.

Material, animals and methods

Animals

Twenty horses (7 mares, 12 geldings, 1 stallion) between 3 and 23 years (median 12 years) with sinonasal disease were included in this study. The population consisted of 14 Standardbreds, 3 Quarter Horses, 1 Pony and 2 Thoroughbreds). The patients were referred to the Equine Clinic of the University of Veterinary Medicine Vienna because of unilateral nasal discharge (n=18), bilateral nasal discharge (n=1) or the presence of a maxillary draining tract (n=1).

History

The history of each patient was recorded and included data of breed, age, gender, duration of clinical signs and treatment(s) prior to referral.

Clinical examinations

All horses were subjected to a thorough clinical examination (*Baumgartner* 2002). Selected findings including elevated body temperature, presence of nasal discharge, facial swellings, abnormal respiratory noise and compromised nasal airflow were recorded separately for further evaluation (Tab. 1).

Table 1 Case history and clinical signs of patients
Vorberichte und Klinische Anzeichen der Patienten

Case history and presenting signs	Horses, n=
Duration of clinical signs < 10 days	11
Duration of clinical signs > 10 days	9
Treatment prior to referral	6
Unilateral nasal discharge	18
Bilateral nasal discharge	1
Maxillary fistula	1
Quidding	2
Elevated body temperature	4
Facial swelling	3
Respiratory noise	3
Nasal airflow obstruction	2

Thermographic measurements

Thermographic examinations were always performed in the same room. The room temperature was measured prior to and during all measurements to ensure the temperature did not exceed 30°C at any point of time during measurements (*Turner* 1991). The patients were not sedated and exercised for at least 4 h prior to thermography and were not clipped at the head. The camera was placed at a distance of approximately 1.5 meters in front and at both sides of the horse's heads. The horses were restrained in stocks and the head-collar was removed from the head and placed around the neck several minutes before the start of the measurements to avoid pressure marks and superimposition during thermography. For the same reason excessive palpation of the head was avoided immediately before measurements.

Lateral and frontal thermographic images were obtained using an infrared camera (Variocam, InfraTec®). Subsequently the thermographic images were analysed with IRBIS® software. Surface temperatures in a defined area (area of interest, AOI) overlying the right and left maxillary sinuses were depicted as colour gradients on the thermographic pictures (Fig. 1-4). These areas were defined by three lines on each side on the frontal images: A horizontal line 1 cm rostral to the orbit was drawn. The second lines were located parallel and 1 cm dorsal to the facial crest. Finally a third line was drawn intersecting the second line at the rostral end of the facial crest and the first line at a distance of 2 cm from the median line (Fig. 1).

The definition of areas of interest on head-on thermographic pictures was a precondition to obtain symmetric, comparable data sets of the patients. The horses were assigned to different groups based on differences of the mean temperatures overlying the maxillary sinuses. The mean temperature of the respective right and left AOI s was calculated and temperature differences (ΔT) between the affected and the unchanged side were recorded. Based on these findings the patients were assigned to one of three groups: Horses in group 0 did not show any or just minimal thermographic differences

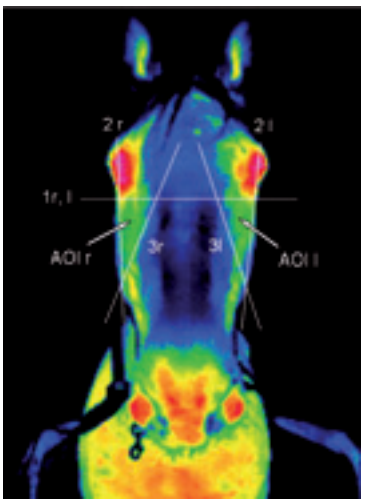

Fig. 1 Frontal thermographic image. 1, 2, 3: Lines defining the area of interest (AOI r, AOI l) overlying the right (r) and left (l) maxillary sinuses (arrows).
Frontale thermographische Aufnahme. 1, 2, 3: Die Linien definieren die AOI über den rechten und linken Kieferhöhlen

(ΔT <0.7°C) between the left and right AOI. Animals in group 1 displayed a significantly warmer AOI on the affected side compared to the contra lateral side (ΔT >0.7°C). Finally, horses in group 2 displayed lower surface temperatures of the affected AOI compared to the unaffected side (ΔT = 0.8°C).

Examination of the oral cavity and the upper respiratory tract

The horses were sedated with xylazine 0.05 mg/kg BWT, i.v. (Chanazin®) or detomidine 0.01 mg/ kg bwt i.v. (Domose-

dan®) combined with butorphanol 0.01 mg/kg BWT, i.v. (Butomidor®). The examination of the oral cavity was performed as described by *Simhofer* et al. (2008). Particular attention was paid to the number of teeth, fractured cheek teeth, draining tracts and patent pulp cavities.

Endoscopic examination of the oral cavity was performed using a rigid (47 cm, 90°) oral endoscopic optic (Dr. Fritz®), a

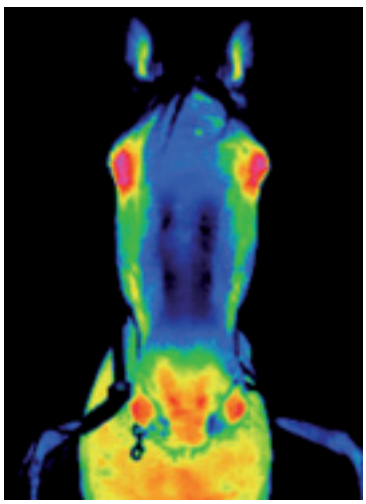

Fig. 2 Frontal thermographic image of a horse with symmetric temperature gradients over the maxillary sinuses (group 0).
Frontale thermographische Aufnahme eines Pferdes mit symmterischen Temperaturgradienten über den Kieferhöhlen

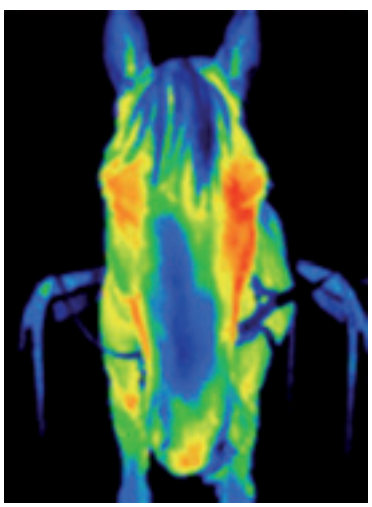

Fig. 3 Thermographic image of a horse with acute sinusitis. The AOI on the left side is significantly warmer (orange and red) compared to the right side (group 1).
Thermographisches Bild eines Pferdes mit akuter Sinusitis. Die AOI ist auf der linken Seite signifikant wärmer (orange und rot) als auf der rechten Seite (Gruppe 1)

Xenon lightsource (Eurolight Praxis; 230 V, 50/60 Hz, 150 W, Dr. Fritz®), a 3-Chip-Colour-Video-Camera and control-unit (Eurocam Typeflex, 230 V, 50/60 Hz, Dr. Fritz®). Endoscopic examination of the nasal passages and the pharynx was performed using a flexible bronchoscope (100 cm, 1 cm diameter, Storz®). Special attention was paid to the caudal end of the middle meatus (Apertura nasomaxillaris), inflammatory signs of the dorsal and ventral conchae and the ethmoturbinates. The presence of pathological findings was recorded.

Diagnostic imaging

Lateral and lateral 30°oblique radiographic views of the maxillary sinuses and cheek tooth arcades were routinely obtained of all horses using two types of radiographic cameras (Gierth® HF 100 Plus Ultraleicht and Siemens® Opti 150/40/82 C-100L). For digital development two systems (Fuji® Computed Radiography DMS CRT Image Console HI-C655 and Kodak® Direct View System CR850) were used. In 12 cases additional projections (fronto-mandibular-, oblique- and caudolateral-rostromedial views) were obtained. The fronto-mandibular view was used in selected cases of suspected empyema of the ventral conchal sinuses. Caudolateral-rostromedial projections were used to evaluate the lateral aspects of the maxillary and frontal bones and sinuses. All radiographic images were evaluated by a radiologist and a clinician.

Computed tomography was performed in selected cases (n=9) to confirm or exclude apical infections of maxillary cheek teeth. Computed tomography was performed under general anaesthesia in dorsal recumbency as described by *Henninger* et al. (2003). The images were evaluated by a radiologist and a clinician.

Diagnosis

Based on the clinical findings and additional endoscopic-, radiographic- and, in some instances, CT diagnoses, a presumptive diagnosis was made and the horses were assigned to 1 of 4 groups for subsequent statistical analysis (Tab. 2). In group 1 all

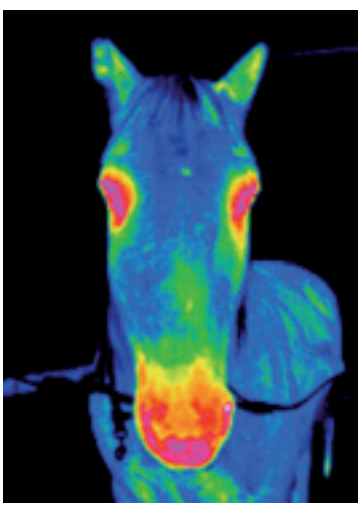

Fig. 4 Thermographic image of a horse with chronic sinusitis. The AOI on the right side is significantly colder (green and blue) compared to the left side (group 3).
Thermographisches Bild eines Pferdes mit chronischer Sinusitis. Die AOI ist auf der rechten Seite signifikant kälter (grün und blau) als auf der linken Seite (Gruppe 3)

horses with primary sinusitis were summoned. In these patients affections of the caudal maxillary cheek teeth was ruled out. All horses with a confirmed diagnosis of secondary (dental) sinusitis were assigned to group 2. Group 3 consisted of animals with other diagnoses (progressive ethmoid haematomas (PEH), sinus cysts and trauma-associated sinusitis. Finally patients with an unknown aetiology of sinusitis were summoned in group 4. In these cases a tooth root infection was suspected, but lacking owner compliance precluded further diagnostic procedures.

Table 2 Diagnoses and thermographic findings in 20 horses with sinonasal disease / *Diagnose und thermographische Befunde bei 20 Pferdes mit sinonasaler Erkrankung*

Diagnosis	Total	Primary sinusitis	Dental sinusitis	Other cases of secondary sinusitis	Sinusitis of unknown origin
number of cases	20	4	10	4	2
Thermographic findings					
Group 0	10	2	6	0	1
Group 1	10	2	4	3	1
Group 2	1	0	0	1	0

Statistical analysis

Thermographic results were compared with the findings of the four diagnostic groups using the Spearman–Rho test for multivariant ANOVA analysis. Additionally, clinical findings (facial swelling, elevated body temperature, treatment prior to referral and duration of clinical signs) were compared to thermographic findings using the same test.

Results

Clinical findings

Presenting symptoms are listed in table 1. Most horses (n=19; 95.0 %) were referred because of unilateral or bilateral nasal discharge. One horse was presented at the clinic because of a facial (maxillary) draining tract. Prior to referral 6 horses received antimicrobial therapy (Trimethoprim/Sulfonamid, Enrofloxacin, Penicillin, Streptomycin, Marbofloxacin) and 2 of these horses were additionally treated with secretolytic medication (Acetylcystein).

Intraoral findings

Oral examinations revealed patent pulp horns in 4 horses, fractured teeth in 5 animals and draining tracts in 3 patients. In one horse a supernumerary cheek tooth was found; a loose cheek tooth (periodontal disease) was found in another animal. Periodontitis with impaction of feed material (n=1) and diastema formation (n=2) were also diagnosed. Endoscopy of the nasal passages revealed purulent discharge originating from the nasomaxillary orifice (drainage angle) in 13 animals. Reduced space of the nasal passages was diagnosed in 4 animals. In 2 patients swellings of the mucosal membranes overlying the nasal conchae were encountered. Progressive ethmoid haematoma (PEH) was diagnosed in 1 horse.

Thermographic findings and diagnosis

The results of all thermographic measurements are listed in table 2. No significant differences of the superficial temperatures between the right and left AOI's were found in 9 horses (group 0). Two of these animals suffered from primary sinusitis, in 6 animals secondary (dental) sinusitis was diagnosed. In one patient the aetiology of the sinusitis could not be diagnosed because of lacking owner compliance.

Markedly higher temperatures within the AOI overlying the affected side were diagnosed in 10 horses (group 1). In two of these horses a diagnosis of primary sinusitis was made, in 4 animals secondary (dental) sinusitis was diagnosed. Secondary sinusitis unrelated to dental problems was found in 3 patients and no definitive diagnosis could be made in 1 horse. A clear lower temperature within the AOI of the affected side was observed in 1 horse (group 2). In this patient chronic sinusitis unrelated to dental problems was diagnosed.

Radiographic findings

Opacity of the maxillary sinuses was present in 19 horses. In 2 cases free fluid levels were detectable and in 6 horses a well circumscribed mass within the sinuses (3 with soft tissue swelling, 2 sinus cysts and 1 ethmoidal haematoma) was found. There were 5 horses where no tooth root abnormalities could be depicted and 12 horses with suspected tooth root infections. In 3 cases a tooth root infection was considered as assured because of definitive radiographic findings. Nasal septum deviation was present in 2 horses.

CT findings

In 9 patients that underwent CT examination the following findings were encountered: A marked thickening of the sinus lining was present in all 9 horses. The maxillary sinuses of all 9 patients contained free fluids or soft tissue masses. Apical infections of at least one maxillary cheek tooth were found in 7 patients. In three horses the infection led to a consecutive thinning of the maxillary bone overlying the maxillary sinus; thickened (sclerotic) maxillary wall was found in 4 patients. Isolated bony fragments (sequestrate) were seen in 2 horses, deviation of the nasal septum was encountered in another two animals. Deformation of the bony orbita (n=3), involvement of the infraorbital canal (n=3) and soft tissue swellings of the facial region (n=2) were the remaining diagnoses.

Diagnostic results

Diagnoses included 4 cases of primary sinusitis, 10 horses with confirmed dental sinusitis, 2 animals with secondary sinusitis secondary to sinus cysts, 1 with a history of trauma, 1 with progressive ethmoidal haematoma and 2 cases of sinusitis of unknown origin. In both cases with unknown aetiology lacking owner compliance or financial constraints precluded further diagnostic procedures (CT).

Statistical analysis

No significant correlation between the thermographic findings and facial swellings, elevated body temperature, treatment prior to referral and duration of clinical signs could be detected. No correlation between thermographic findings and the definitive diagnosis could be found.

Discussion

In all horses clear thermographic images could be obtained. In order to produce reliable results, thermography was performed under controlled environmental conditions as suggested by *Turner* 1991. Consequently the thermographic examinations were performed in a room of approximately 20 m2 providing a constant and uniform temperature range. All windows and doors were closed prior to and during examinations. *Tunley* and *Henson* (2004) demonstrated that time for equilibration, as reported in previous studies, is not needed. To avoid artefacts our patients were not sedated and not exercised prior to thermographic examinations, and were examined with a dry and clean hair coat of uniform length (*Turner* 1991). The surgical sites in all of our patients were clipped prior to surgery which precluded follow up examinations.

The results of the present study suggest a limited diagnostic value of thermography for the detection of sinusitis in horses. Although 10 horses displayed positive thermographic findings, in another 9 horses no or just minimal temperature differences of the tissues overlying the diseased maxillary sinuses compared to the unaffected side were detectable. Negative thermographic results in affected horses may be obtained in case of affection of deeper anatomical structures. Although the sinuses communicate with each other, an infection of the conchal sinuses does not inevitably cause acute inflammatory reactions in the maxillary sinuses. Alternatively elevated temperatures caused by infections and inflammatory disease in the dorsal or ventral conchal sinus or their respective bullae might not be transduced to the surface and might consequently not be detectable using thermography. Negative thermographic results might also be obtained in chronic cases or when anti-inflammatory or antibiotic treatment has been performed prior to referral. Horses with chronic infections, especially in conjunction with inspissated pus usually do not present with signs of acute inflammation like regionally elevated temperature. However, in this study no significant correlation between thermographic findings and duration of clinical signs or treatment before referral could be identified.

In one horse presenting with a bony deformation of the maxilla, slightly decreased temperature of the area overlying the affected sinuses was diagnosed. So called cold-spots were described by *Turner* (1991) and occur for example as a consequence of decreased bloodflow in areas of massive swellings.

Utilising computer software, it was possible to measure the mean temperature of the area overlying the maxillary sinuses and compare the temperatures of the left and right sides in order to obtain objective data. However, it was difficult to circumscribe the maxillary sinuses exactly on a thermographic image.

Finally the diagnosis of sinusitis in horses is based on a variety of examination techniques. Alhough radiography is a well-established technique for the diagnosis of equine paranasal disorders, the specificity of this method to diagnose secondary (dental) disease has been described as low (*Gibbs* and *Lane* 1987). In the present study a definitive diagnosis based on radiography was obtained in only 4 of 11 cases of dental sinusitis. These results are similar to those reported by *Gibbs* and *Lane* (1987), where secondary (dental) sinusitis was diagnosed on radiographs with a confidence of only 50-57 %. Computed tomography (CT) is a time consuming and elaborate procedure but superior to radiography, because no superimpostions of bone and soft tissue occur (*Henninger* et al., 1998). In the present study half of the cases with sinus disease presented with negative thermographic findings. Hence a negative thermographic result does not necessarily exclude the presence of sinusitis. However, if a temperature difference to the contralateral maxillary sinuses is observed, a presumptive diagnosis of sinus affection can be made. But despite positive thermographic results, the aetiology of the sinusitis will still remain uncertain. Consequently the diagnostic value of thermography in horses with sinus disease is regarded as limited.

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