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Advantages and limits of computed tomography in the diagnosis of equine dental disease

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Introduction
Computed tomography (CT) is increasingly used in equine medicine as a valuable diagnostic tool. CT provides detailed cross sectional images of tissues with good bony and soft tissue contrast, eliminating the problem of superimposition (Heufelder et al. 1994; O’Brien and Biller 1998; Solano and Brawer 2004). CT examination of the equine head region is indicated in cases where clinical and radiographic examinations are inconclusive, when the exact localisation and extension of a lesion is needed for targeted therapy planning (Annear et al. 2008) and also to monitor cases with ongoing disease following treatment. Computed tomography has proven to be very useful in the diagnosis of fractures, dental disease, infection and neoplasia of the equine paranasal sinuses. General anaesthesia is usually required for equine CT examinations, but more recently some clinics offer CT examination on sedated, standing horses (Nelson 2008).

Differentiation of equine dental and periodontal tissues
A major advantage of CT is that the complex anatomy of the hard dental tissues and pulp system can be clearly differentiated. The peripheral layer of cement is hypodense compared to adjacent enamel. The hypodense zone of peripheral enamel extends from the clinical crown towards the apical region. Dentine is less radiodense than enamel and surrounds the hypodense pulp cavities (Puchalski 2006) which can be followed over their length. A column of dense secondary dentine lies over each pulp canal at the occlusal surface of healthy teeth. The infundibulae (rostral and caudal) are clearly seen in the maxillary cheek teeth. The hypodense central infundibular vascular channel must not be mistaken for an infected pulp with gas inclusions! The periodontal ligament appears as a narrow soft-tissue structure that separates the tooth from the surrounding alveolar bone. In healthy teeth a thin bony layer (lamina dura denta) lines the alveolus. Several publications have described the CT anatomy of the equine head (Tietje et al. 1996; Smallwood et al. 2002; Solano and Brawer 2004; Probst et al. 2005; Nöller et al. 2007; Rodriguez et al. 2008), including a recent study that described equine CT dental anatomy in detail (Windley et al. 2009a,b).

Advantages and limits of CT-diagnosis

Apical infection
Characteristic features are hypodense widening of the apical periodontium, sclerosis and deformation or disintegration of the apical dental lamina. Thickening of the overlying periapical soft tissue (granuloma formation) with or without gas inclusions, are also frequently encountered. Changes of the calcified dental tissues, in particular deformation or fragmentation of the tooth roots, occur in long standing cases (Puchalski 2006). In some chronic cases, considerable amounts of cement are deposited irregularly around the apex.

Pulpitis and pulp necrosis
Hypodense (black) areas indicating the presence of gas within the pulp or root canals are indicative of pulp necrosis. While the presence of gas inclusions facilitates the diagnosis of pulp necrosis in chronic cases, acute pulps is difficult to diagnose on CT images. Only subtle changes might be visible on CT slides which can easily be overlooked.

Dental fractures
Dental fractures are sometimes difficult to diagnose radiographically but they are readily detected on CT images. It is also possible to distinguish between single and multiple pulp cavity involvement (Bienert and Bartmann 2008). However, in some acute cases of dental fractures involving pulp cavities, no signs of pulp reactions are detectable on CT. This might be due to a process of healing by means of production of tertiary dentine or, alternatively, the horse might not have developed visible signs of pulpitis and subsequent periapical infection at the time of CT examination. In the latter type of cases, magnetic resonance imaging (MRI) has been described as a helpful diagnostic tool in the detection of periodontal disease, pulpitis or pulp necrosis (Gerlach and Gerhards 2008a,b).

Infundibular cemental hypoplasia/caries
Wide and air-filled irregular cavities are frequently seen on CT images of clinically normal infundibulae (Puchalski 2006). Although easily diagnosed, infundibular changes are frequently present in horses that do not show any clinical symptoms. In these cases dental extraction is not indicated. The diagnosis of severe infundibular caries penetrating the infundibular enamel is possible using CT examination and is of great help when deciding whether to extract or preserve a maxillary cheek tooth.

Periodontal disease
Signs of periodontal disease range from mild, focal changes (widening of the periodontal space, irregularities in the lamina dura denta, sclerosis, disruption and food and gas pocketing) to excessive destruction of the supporting maxillary or mandibular bones. The exclusion of periodontal disease is a prerequisite for endodontic therapy.

Sinus diseases
Sinusitis is common in horses and can be of primary origin or secondary to dental disease, trauma, cystic lesions, mycotic...
infections or neoplasia (Feige et al. 2000; Puchalski 2006; Nelson 2008). One of the first signs of sinus disease detectable on CT imaging is a focal or diffuse swelling of the sinus mucosa. A varying degree of fluid accumulation or areas of increased density due to inspissated material can also be seen. In cases where the sinuses are entirely fluid-filled, the sinus mucosa will be indistinguishable from the surrounding fluid. In these cases evacuation of sinus exudates prior to CT examination may facilitate evaluation of the extent of mucosal swelling. In long standing cases, chronic distension of the sinuses with exudate can cause deviation of the nasal septum, the facial bones and even dental apices. Chronic sinussitis may also cause thickening, endosteal sclerosis and an irregular periosteal reaction of maxillary (Puchalski 2006) and mandibular bone and new bone formation may be present along the internal and external supporting bony surfaces.

The presence of facial swelling and draining sinus tracts are some of the most common indications for referral of equine patients. Dental disease, dentigerous cysts (heterotopic polyodontia), head trauma, osteomyelitis and infrequently neoplasms account for majority of cases with facial swelling and draining sinus tracts. In most of these cases a definite diagnosis can be obtained radiographically; however, CT can be helpful in the examination of more difficult cases.

**Tumours, neoplastic diseases**

Despite the fact that a specific tumour classification is not possible using CT, the extent and grade of destruction of hard and soft tissues can be clearly evaluated, which enables a more accurate possible treatment plan and prognosis to be given.

**Therapy planning, case monitoring**

In complicated cases of ongoing dental-related disease, a CT examination can be very helpful in the detection of the lesion and planning of subsequent treatment strategies of oronasal fistulae or sequestrations secondary to tooth root remnants, bone necrosis or ongoing osteomyelitis.

**References**


