



Dr Christopher J Pearce,  
BVSc CertEM(IntMed)  
CertES(SoftTissue)  
DipEVDC(Equine) BAEDT  
MRCVS

The Equine Dental Clinic  
Ltd, Wimborne, Dorset  
BH21 5BX, UK

## ANATOMIC AND PATHOLOGICAL CONSIDERATIONS; CASE SELECTION

### Introduction

Endodontics in equine teeth presents a unique challenge for the veterinary dentist. The anatomy of the pulp and infundibular cavities in the horse is a relatively new field of research and there is still much to uncover. The precise anatomy of individual pulp canals e.g. in cheek teeth is becoming clearer through recent studies showing us pulpar communications and age-related separation resulting in new guidelines for treatments and case selection.

Successful endodontic therapy requires an accurate diagnosis, including understanding which part of the endodontic or infundibular system is affected. The anatomy of these is complex, and varies with age, location and pathology. Computed tomography (CT) is increasingly available and can aid diagnosis e.g. of septic pulpitis however this should not be relied upon as a completely reliable imaging modality as there are still inconsistencies imaging the endodontic system. Magnetic resonance imaging (MRI) has considerable promise as a reliable imaging modality to diagnose the vitality of pulp canals and assist in guiding treatments but the availability for many practitioners is currently low.

### Pulp

Pulp is a soft tissue within the dental pulp cavities containing a variety of connective tissues, nerves, blood, lymphatic vessels, and nerves. Recently erupted teeth have a large common pulp, but with age and deposition of secondary dentine, this becomes divided into separate pulp horns. Dacre *et al* developed a numbering system for these pulps<sup>(1)</sup>; however, a later pulp numbering system suggested by Du Toit<sup>(2)</sup> is recommended as a simpler (Fig1). All incisors and canine teeth have a common single pulp.

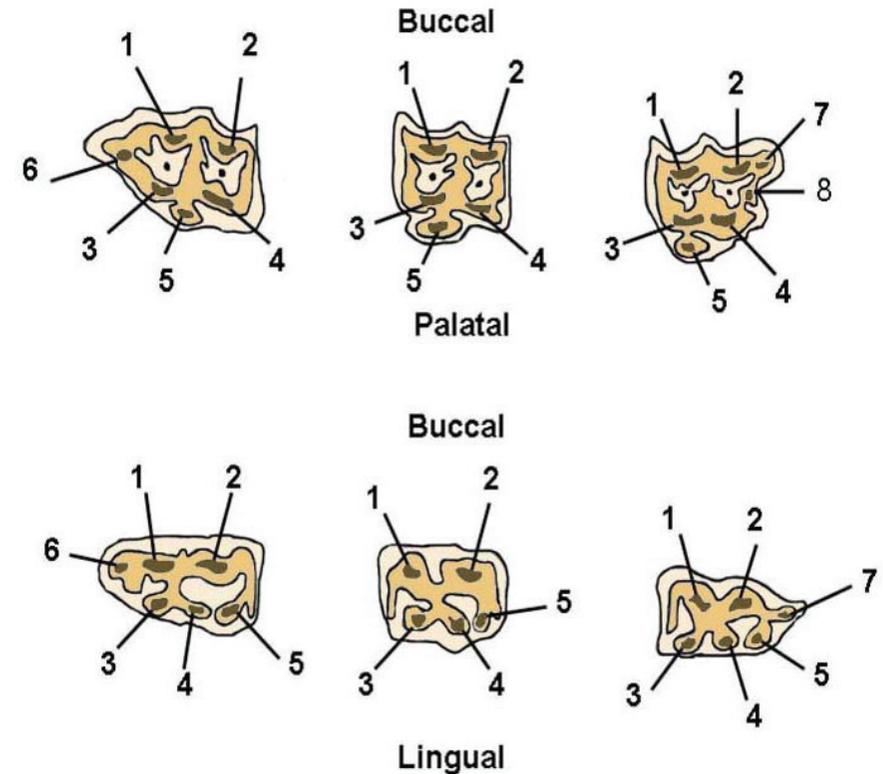


Fig 1. Pulp anatomy (duToit *et al*, 2009). Top row displays maxillary teeth, lower row mandibular teeth. From left to right the teeth are Triadan 06, 07-10, 11.

Root formation in a hypsodont tooth starts after eruption and occlusion with its counterpart and the normal wear process of attrition has started. A brachyodont cheek tooth has a common pulp chamber within the crown, while the immature equine cheek tooth has a common pulp chamber in the apex. This presents a unique challenge regarding equine cheek teeth – the pulp system can be considered ‘upside down’ compared to brachyodont dentition (Fig 2).

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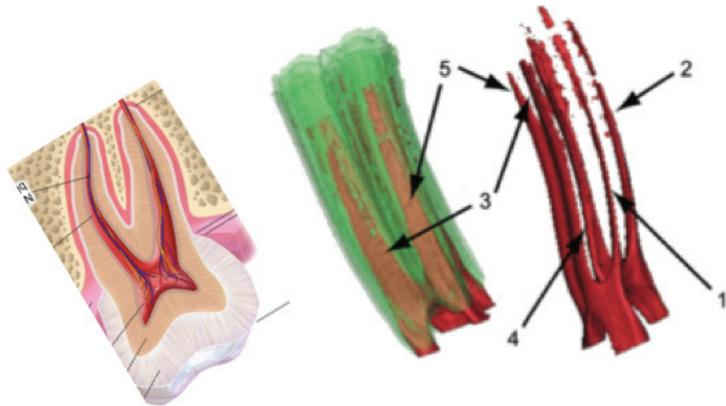


Fig.2 Brachydont tooth (left, occlusal surface bottom) shows common pulp chamber within clinical crown; hypsodont tooth (right, occlusal surface top) shows common pulp chamber at apex. (Right image courtesy Windley et al 2009)

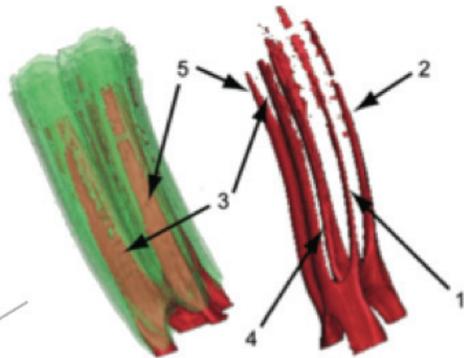


Fig 3. Images showing computed tomographic reconstructions of cheek teeth showing the pulpar separation at different eruption ages (Kopke, Angrisani, Staszyc 2012).

Following root development, the equine pulp chamber divides into separate pulp cavities that in turn, due to the progressive deposition of secondary dentine, decrease in diameter with age<sup>(3)</sup>. Pulp canals become separated into individual canals or 'groups' with age<sup>(4)</sup>. This is complex with much variability however this can give the practitioner a guide to which pulp canals may be affected, and if the entire endodontic system is likely to be affected, therefore potentially guiding treatment (Fig 3). The progressive narrowing of pulp canals through marginal secondary dentine deposition may increase the difficulty of access the pulp canals in an older tooth with endodontic files. Removal of damaged pulp tissue and any contained feedstuff can however be facilitated by the fact that attrition makes the tooth shorter and root development and age result in the pulp horns being totally separated, as well as being reduced in size.

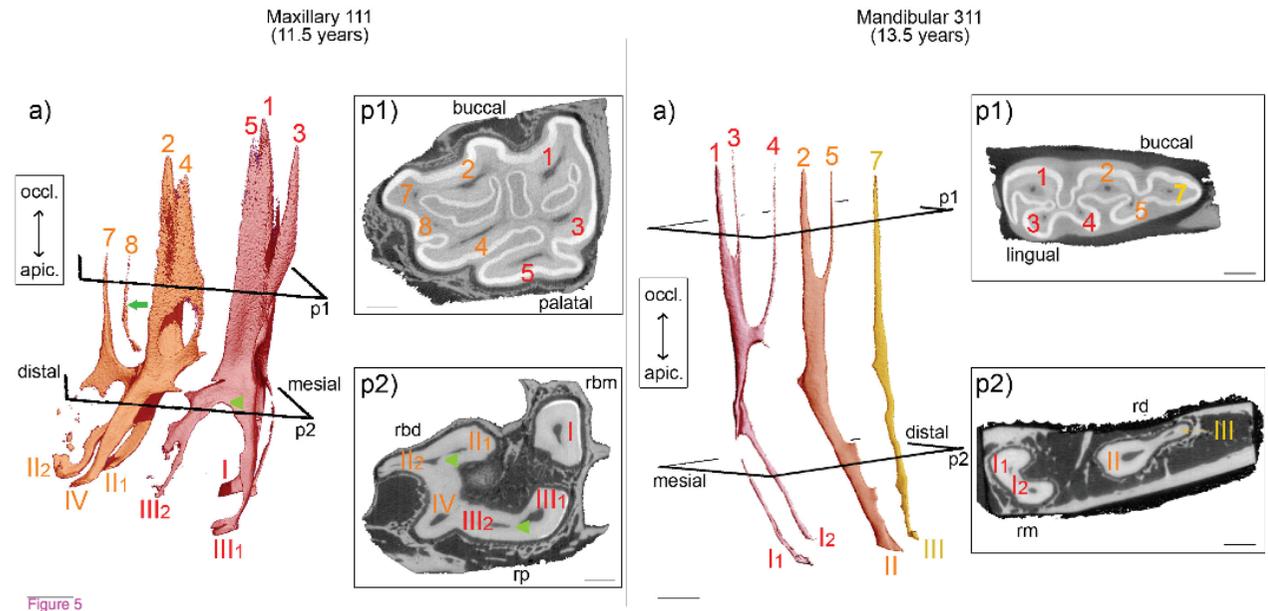


Figure 5

### Pulpitis

Pulp tissue may become infected or severely inflamed through fracture, infundibular disease or most commonly through *anachoresis* – the establishment of blood-borne bacteria within the inflamed pulp. Sequelae are:

1. Rapid sepsis and death of the entire pulp system, communicating at the apex e.g. young horse with acute apical 'abscess'; pain, pyrexia, swelling, sinusitis.
2. Reaction to pulpitis and apical bridge / reparative dentine formation / apical cementosis sealing the septic and necrotic areas, usually occlusally. Continued occlusal attrition results in secondary dentine defects and influx of food into the pulp system.

3. Pulp death and ineffective calcified apical barrier, affecting some or all pulp canals leading to pulp caries, progressive apical periodontitis, sinusitis, discharging tracts externally or orally, pathological fracture.

### Infundibular anatomy

All incisor teeth have a single, shallow infundibulum (commonly referred to as the 'cup') compared to maxillary cheek teeth that have two infundibula per tooth (rostral and caudal). Cheek teeth infundibula are considerably deeper structures, parallel sided for much of their length, and extending almost 80-90% of the distance to the root apex. This reduces with age as true roots develop.

### Infundibular cemental hypoplasia / infundibular hypocementosis (IH)

This developmental abnormality most commonly affects the more apical aspect of infundibula although rarely there may be more complete or even total absence of cementum within infundibula which may be described as complete cemental hypoplasia, aplasia or a patent infundibulum. Recent studies have shown that the Triadan (maxillary) position 11 tooth is most commonly affected by apical cemental hypoplasia, however the largest defects and complete hypoplasia most commonly affect the 09 teeth, with 8.2% of maxillary Triadan 09 teeth having completely aplastic infundibula, and only 3% having normally filled infundibula<sup>(3)</sup>. Many such lesions are bilaterally symmetrical. Infundibula may also fail to close at the apex, resulting in apical 'patency' allowing contamination of the apex directly from even small infundibular defects<sup>(5)</sup>.

### Infundibular caries (IC)

IH cavities once exposed through surface attrition will become impacted with food material resulting in progressive caries. Large deep lesions, exposed early, may result in enamel loss, increased wear rates, dentine caries, pulp contamination, apical sepsis or pathological fracture. Infundibular caries was implicated as the cause of 16% of apical infections of maxillary cheek teeth in one study<sup>(6)</sup>. A modified Honma classification system (MHCS) may be used for caries grading for infundibula:

Grade 1 Caries of cementum only

Grade 2 Caries of cementum, enamel

Grade 3 Caries of cementum, enamel, dentine

Grade 4 Coalescence of rostral and caudal infundibula (both grade 3)

Grade 5 Pathological fracture / structural loss

### Case selection for pulpitis / fractures

The author uses these three broad categories to describe the vitality of teeth in cases of cheek tooth pulpar pathology and fracture, and subsequently to decide upon a treatment strategy:

Category of cheek tooth pathology / endodontic status	Description	Action
Category 1	Pulp has survived any insult, tertiary dentine may be present, no apical infection evident, no occlusal dentine defects visible (some fractures may be within this category)  Grades 1-2 IC	No action required; monitor closely (up to 3 years)
Category 2	No evidence apical disease, reparative dentine / pulp closure apically, occlusal pulp exposure and caries is present  Grade 3+ IC	Treatment using endodontic / restorative techniques is appropriate
Category 3	The apex and some or all of the pulp system is septic / compromised (includes some fractures including <i>all</i> maxillary saggital fractures)  Grade 3-4 IC with apical sepsis  Grade 5 IC	Full endodontic therapy or extraction of tooth required   Extraction

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