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Donkey dental anatomy. Part 1: Gross and computed axial tomography examinations

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Abstract

Post-mortem examination of 19 donkey skulls showed that donkeys have a greater degree of anisognathia (27% width difference between upper and lower jaws) compared to horses (23%). Teeth ($n = 108$) were collected from 14 skulls and examined grossly and by computed axial tomography (CAT). A greater degree of peripheral enamel infolding was found in mandibular cheek teeth (CT) compared to maxillary CT ($P < 0.001$). A significant increase in peripheral cementum from the apical region to the clinical crown was demonstrated in all CT ($P < 0.0001$). All donkey CT had at least five pulp cavities with six pulp cavities present in the 06s and 11s. A new endodontic numbering system for equid CT has been proposed. A greater occlusal depth of secondary dentine (mm) was present in older donkeys (>16 years) than in the younger (<15 years) donkeys studied. Based on gross and CAT examinations, donkey dental anatomy was shown to be largely similar to that described in horses.

Keywords: Donkey; Equid; Dental anatomy; Radiology; Gross; Computed axial tomography; CAT

Introduction

Our understanding of the nature and treatment of equine dental disorders has advanced rapidly in the last few years demonstrating the common occurrence of numerous dental disorders in horses and highlighting the importance of good dental care in the welfare of the horse (Dixon and Dacre, 2005). Many recent studies have documented normal equine dental anatomy and pathology by gross, radiological, histological and ultrastructural examinations (Dixon and Copeland, 1993; Kilic et al., 1997a,b,c,d; Dixon et al., 1999a,b; 2000a,b; Dixon, 2002, 2005; Mitchell et al., 2003; Dacre, 2005b). In contrast, the limited literature on donkey dental gross anatomy includes just two gross anatomical (Bunger and Hertsch, 1981; Muylle et al., 1999) and one radiological study on cheek teeth (CT) development (Misk and Seilem, 1999).

Dental disorders have recently been recognised as a significant welfare problem in donkeys in the UK and abroad, including in the ageing population of donkeys at The Donkey Sanctuary farms in the UK (Trawford and Crane, 1995; Dacre et al., in press). A study of Indian donkeys found that 65% of donkeys examined for poor body condition suffered from serious dental disorders (Roy, 2002). In addition to the obvious welfare problem of dental disease in donkeys, in developing countries such disorders can have enormous economic effect on poorer people that sometimes depend on a single donkey to earn a living in agriculture or by transporting goods. Very few comprehensive studies on donkey dental disease have been performed to date, although pathological changes associated with dental displacements, diastema and periodontal disease has been noted in older donkeys on routine oral examinations (Dacre et al., in press).

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Most of our limited knowledge of donkey dentistry has been extrapolated from equine research and although the donkey (*Equus asinus)* is of the same family (Equidae) and genus (*Equus*) as the domestic horse (*Equus caballus*), they are a different subgenus and as such cannot be assumed to have similar anatomy of all structures. The aim of this study was to describe the normal dental anatomy of the domestic donkey using gross examination and computed axial tomography. Only when normal donkey dental anatomy has been clearly defined, can studies investigating donkey dental disease be rationally performed.

Materials and methods

Donkey teeth

The skulls of 19 donkeys (median age 26 years) that died or were euthanased on humane grounds at The Donkey Sanctuary, Sidmouth, UK, were assessed at post mortem examinations for the degree of anisognathia present. Grossly normal teeth were extracted at random from 14 other donkeys (median age 19 years) and were fixed in 10% buffered formalin. The age of the donkey and Triadan number of each tooth was recorded. A total of 108 teeth were extracted including 40 maxillary CT, 42 mandibular CT and 26 incisors. The median age of the donkeys from which these teeth were obtained was 18, 20 and 20 years, respectively.

Gross examination

Measurements of the 19 skulls for anisognathia were obtained using digital callipers (Knighton Tool Supplies) calibrated in millimetres to two decimal places. Anisognathia is defined as greater maxillary width compared to mandibular width. Measurements were obtained from the buccal aspects of the occlusal surface of each tooth to the contra-lateral tooth for each of the six Triadan positions on the mandible and maxillae (e.g. 106–206). The ratio of each maxillary measurement over corresponding mandibular measurement was determined (e.g. ratio of distance of 106–206 to 306–406). The percentage anisognathia is represented as $(a/b - 1) \times 100$, where a and b are the distances from buccal occlusal margin of corresponding contra-lateral maxillary CT and mandibular CT, respectively. Measurements were not taken if a tooth was displaced, and clearly could not be obtained when teeth were missing.

Gross measurements including, total tooth length (occlusal surface to end of visible enamel – although the crown to root junction was not always well defined), latero-medial and rostro-caudal widths were obtained on all intact teeth (82 CT and 26 incisors) using an electronic digital calliper (Knighton Tool Supplies).

Computed axial tomography

All extracted teeth were imaged using a Somatom Esprit CAT scanner (Siemens AG). A spiral series of images (1.5 mm in depth and 0.75 mm overlap) was taken of each tooth and analysed using Syngo A40A software (Siemens AG). Measurements taken included: total length of teeth – excluding roots (enamel-free areas) if present, rostro-caudal (mesio-distal) and medio-lateral (palatal/lingual-buccal) width of teeth at the occlusal surface, length of pulp cavities identifiable on CT, depth of secondary dentine at the occlusal surface of pulp cavities, latero-medial width of pulp cavities at (a) sub-occlusal, (b) mid and (c) pre-apical level and densities (in Hounsfield units) of enamel, peripheral and infundibular cementum, primary and secondary dentine and pulp on transverse tooth image at defined locations of these dental tissues (Fig. 1).

Cheek teeth peripheral enamel infolding

Sub-occlusal transverse sections of 34 mandibular teeth and 34 maxillary teeth, obtained approximately 5 mm below the occlusal surface, were scanned (Hewlett-Packard Scanjet 4850) and recorded digital images were stored on a computer. Measurements of the total tooth perimeter and enamel perimeter were obtained using an image analysis computer programme (ImageJ 1.37, Image processing and analysis in Java).

Peripheral cementum area

Transverse sections of 26 maxillary and 26 mandibular CT were scanned (Hewlett-Packard Scanjet 4850) to obtain digital images which were measured on a computer using ImageJ (ImageJ 1.37, Image processing and analysis in Java). Three transverse sections were measured per tooth at different longitudinal levels (A = sub-occlusal; B = mid tooth; C = apical third of tooth). The total transverse area of the tooth and area of peripheral cementum were measured and their ratio was calculated to

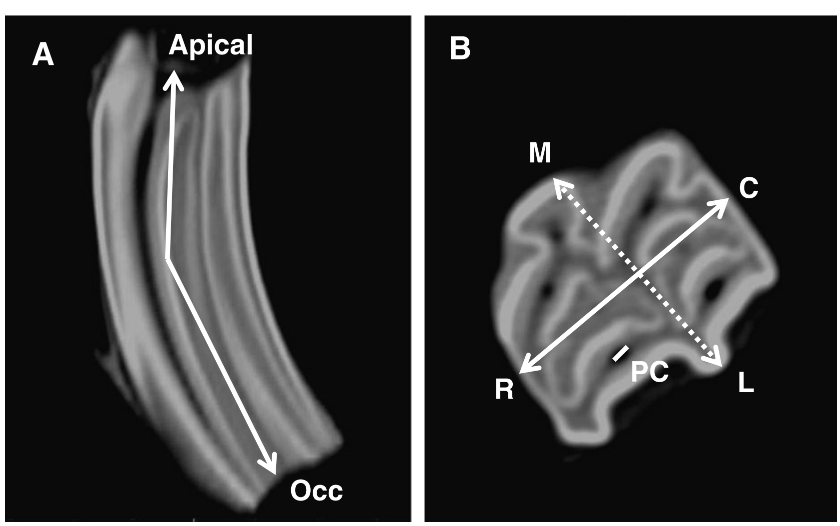

Fig. 1. Mid-longitudinal (A) and sub-occlusal transverse (B) CAT images of a maxillary cheek tooth from a 6 year old donkey, illustrating measurement of tooth length (white line with arrows) (A), rostro-caudal width (white line with arrows), medio-lateral width (dashed line with arrows) and pulp cavity width (white line) (B). Note that the tooth length had to be measure in two angled lines due to the longitudinal curvature of the tooth. Apical = apical region of tooth; Occ = occlusal surface; R = rostral (mesial); C = Caudal (distal); M = medial; L = lateral; PC = pulp cavity.