Three cases of osteoma and an osseous fibroma of the paranasal sinuses of horses in South Africa

I Cilliers[a*], J Williams[b], A Carstens[a] and N M Duncan[b]

ABSTRACT

Four horses were presented to the Onderstepoort Veterinary Academic Hospital with histories of facial asymmetry, nasal discharge or obstruction of normal nasal passage airflow. Radiographic examination of the maxillary sinuses of 2 cases revealed well circumscribed, unilateral, mineralised masses; the other 2 cases showed less mineralisation. The masses were accessed for further investigation by surgically created frontonasal bone flaps or trephination of the maxillary sinuses. Diagnosis of osteoma was confirmed histopathologically in 3 of the cases and of ossifying fibroma in the 4th. Two horses were euthanased directly after surgical intervention due to poor prognosis. Osteomas are by nature expansile tumours and follow the complex communication of the sinuses, and therefore are not all amenable to surgical removal. Osseous fibromas are large, solitary, expansile lesions that are rare in all species but reported most frequently in horses. They have an apparent predilection for the rostral mandible of the horse.

Key words: computed tomography, frontonasal bone flap, histopathology, horse, maxillary sinus, osteoma, osseous fibroma, ossifying fibroma, radiography, trephination.

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INTRODUCTION

Neoplasia of the paranasal sinuses in horses is uncommon[4,26,28]. Tumours reported to develop within the sinuses include squamous cell carcinoma, adenocarcinoma, fibrosarcoma, haemangiosarcoma, osteoma, ossifying fibroma and ameloblastic odontoma[6]. The most common neoplasm involving the paranasal sinuses of the horse is squamous cell carcinoma[4,6,26]. A group of fibro-osseous lesions, often with overlapping histologic classification, have been reported in the paranasal sinuses of horses[26]. These include osteomas and osseous fibromas.

Clinical signs of most paranasal sinus neoplasms are generally related to their size, location and pattern of growth. Typical clinical signs include facial distortion, nasal discharge, and obstruction of normal airflow on the affected side. Diagnosis and extent of masses are usually established on interpretation of radiographs, excisional biopsy, histopathology and more recently computed tomography[1,15]. Metastases have rarely been recorded[4,6,17].

Osteomas are benign, slow-growing tumours involving the maxillary[28] and conchofrontal sinuses[21]. They are uncommon in all domestic species but are more often recognised in horses and cattle[23], and they have been reported in foals as young as 4 months of age. The clinical signs may, however, only become evident after several years have elapsed owing to their expansile nature[4]. Male horses are predominantly affected[5,7,14,19,28]. Osteomas are reported to be generally amenable to surgical excision[26], as they usually have a sessile or pedunculated[19,21,26] attachment over a small base and are not infiltrative[1]. Histologically, osteomas consist of initial cancellous bone that may become increasingly compact with time. Soft tissue spaces between the bony trabeculae contain one or more centrally located small-calibre blood vessels, a sparse population of spindle cells and a moderately fibrillar connective tissue matrix, within which adipose tissue and haemopoietic elements may be present[23].

Osseous or ossifying fibromas are large, solitary, expansile lesions that are rare in all species but reported most frequently in horses[23]. They have an apparent predilection for the rostral mandible of the horse[23]. These lesions may replace alveolar and cortical bone, cause loosening and loss of teeth, interfere with mastication of food, and predispose the jaw to pathological fracture. Most cases are reported to occur in animals less than 1 year of age[23]. Osseous fibromas and some cases of osteoma are morphologically similar[23]. There is a possibility that an osseous fibroma may mature into an osteoma[23].

Histologically, osseous fibromas exhibit irregularly-shaped spicules of osteoid and woven bone rimmed with osteoblasts, which are randomly formed in a moderately vascularised, densely-cellular fibro-osseous stroma[23]. The proliferative cells resemble fibroblasts that transform into osteoblasts along the margins of developing bone spicules. There is neither cartilage formation nor a recognisable periosteal membrane border. In a few scattered areas, large, well-developed bony trabeculae may occur, as well as osteoclastic resorption and patchy deposition of lamellar bone. In these areas soft tissue between bone spicules may lose cell and fibre density, thus resembling osteoma histologically.

This study reports 3 cases of osteoma and 1 osseous fibroma at the Onderstepoort Veterinary Academic Hospital, University of Pretoria, South Africa (OVAH). Three of the 4 cases were presented within the last 2 years.

CASE HISTORY

Case 1

An 8-year-old Thoroughbred mare was admitted to OVAH for a breeding soundness examination. On clinical examination facial asymmetry was noted. The maxillary sinus on the right was enlarged and on percussion the sound was dull compared to that of the left sinus. Oral examination revealed no significant abnormalities.

Radiographic examination of the right maxillary sinus was performed (Fig. 1). Dorsoventral, right lateral and 2 oblique views (left/right dorsolateral – right/left ventrolateral oblique) revealed a large (14 × 7 × 10 cm), lobulated, well-marginated, mineralised opacity in the right

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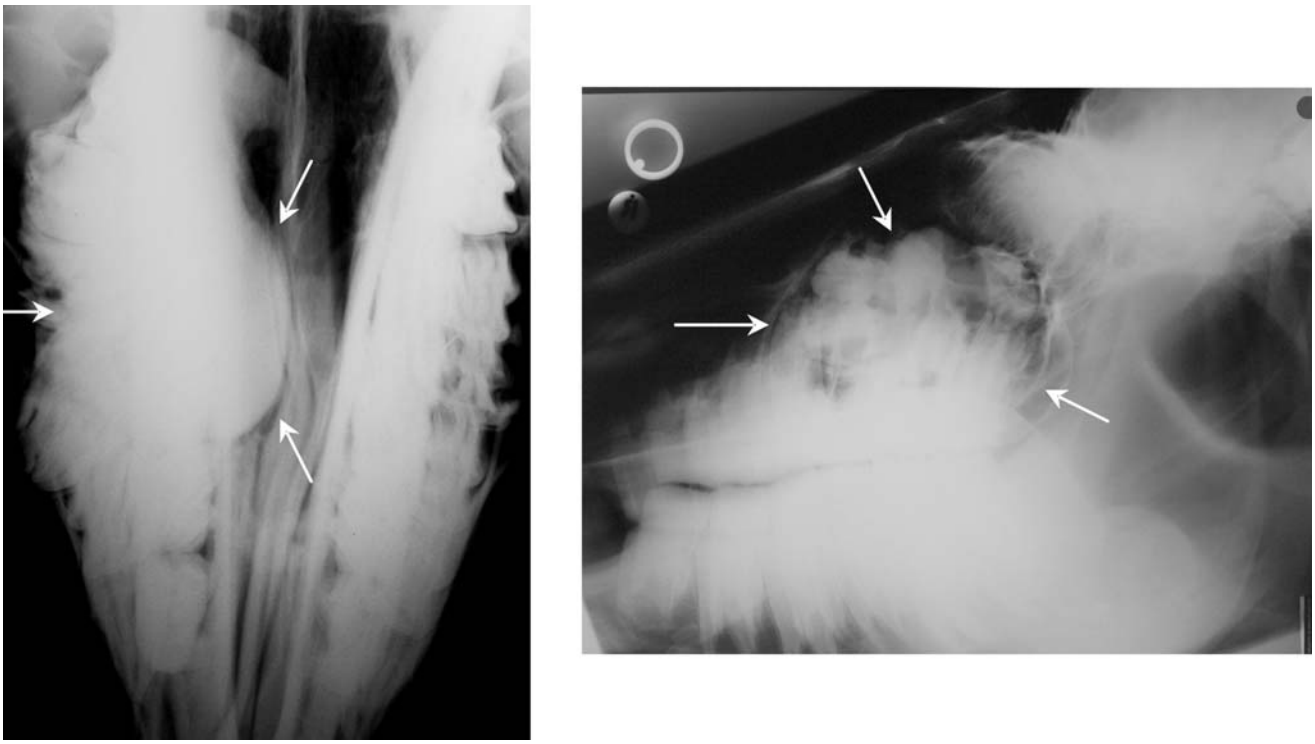

Fig. 1: **Case 1: dorsoventral** (left) **and right latero-left lateral** (right) **radiographs showing the presence of the well-marginated, lobulated, homogenous mineral opacity within the right maxillary sinus, extending from the rostral aspect of premolar 4 to the caudal aspect of maxillary molar 3, focally occluding the right common nasal meatus and moderately displacing the nasal septum to the left.**

maxillary sinus extending into the right ventral conchal sinus and obliterating the right common nasal meatus. The nasal septum was deviated to the left. The right maxillary premolars (PM) were displaced laterally.

The mare was deprived of food but had free access to water for 12 hours before induction of general anaesthesia. Routine pre-operative antibiotics and tetanus toxoid were administered. The mare was sedated with detomidine (Domosedan, Novartis, Isando) (30 mg/kg i.v.) and anaesthesia was induced with glyceryl guaiacol ether (GGE powder, Kyron, Benrose) (50 g i.v.) and ketamine (Anaket, Centaur, Isando) (2.2 mg/kg i.v.). Following induction, anaesthesia was maintained with halothane gas.

The mare was placed in left lateral recumbency and access to the right paranasal sinus was gained by creating a frontonasal flap[9]. The multi-lobulated mass filled the maxillary sinus and had the consistency and appearance of solid, smooth bone. It was firmly attached and immovable. The bony septum between the rostral and caudal maxillary sinuses had been obliterated by the mass, which also appeared to be attached to the infraorbital canal. An attempt was made to fragment the lobulated mass with the help of an osteotome and mallet to facilitate removal. Owing to the extensive size and firm attachment to the sinus walls the mass was impossible to excise completely; approximately one third was removed. Samples of the mass were sent in 10 % formalin for histopathological examination. An opening into the nasal passage was created by partial removal of the medial wall of the ventral conchal sinus[28]. A stockinette pre-loaded with bandages soaked in 0.1 % acriflavine glycerine was packed directly in the sinus to provide haemostasis. The stockinette entered the nasal passage through the opening created in the ventral conchal sinus wall and exited through the right nostril and was sutured to the nostril. The bone flap was reduced and fastened with two 0.6 mm stainless steel wires placed at the lateral corners of the flap. The wound was closed in a routine fashion. The mare recovered uneventfully.

Routine postoperative therapy was administered and the nasal stent gradually removed.

Postoperative radiographs confirmed that a portion of the mass had been removed and that the nasal septum was less deviated than before surgery.

Histopathology of the mass stained with haematoxylin and eosin (H&E) after decalcification in formic acid revealed an osteoma with well-demarcated, peripherally-laminated, poorly cellular, well-vascularised, dense/compact proliferation of intensely eosinophilic, amorphous, fibrillar ground matrix, characteristic of woven and compact bone. Scant collagenous periosteal connective tissue separated the bony mass from a superficial single cell layer of ciliated respiratory epithelium. Closer examination revealed random perivascular osteoblastic/osteocytic proliferation and lacuna formation, with centripetal mineralised woven bone matrix deposition around blood vessels of varying sizes. Some areas appeared more cellular than others, with the former also exhibiting more immature characteristics at cellular (i.e. blastic) and ground matrix (immature collagen deposition and mineralisation) level. Progressive laminated osseous expansion with central blood vessels showed resemblance to Haversion systems in long bones. The mitotic index was very low (<1 per high power field). No osteoclasts were found (Fig. 2).

Case 2

A 9-year-old Warmblood gelding with obvious facial asymmetry ventral to the right orbit was referred to OVAH. Radiographs of the paranasal sinuses revealed a multilobulated mineralised mass (8 × 5 cm) in the right rostral maxillary sinus. It was closely associated with the right infraorbital canal, which was displaced dorsally. A fluid line was present in the rostral maxillary sinus. The owners opted to treat conservatively and follow-up radiographs were made 3 months later. The mass had increased to a size of 10 × 8 cm, with reduction in overall opacity and more radiolucent areas within the mass (Fig. 3a). On the dorsoventral view (Fig. 3b), the mass extended to the lateral wall of the maxillary sinus.

Routine pre-operative planning and

protocols similar to those described in case 1 were followed before induction and the horse was induced and anaesthetised as previously described and placed in left lateral recumbency. A frontonasal bone flap was created and the entire brittle mass was removed piecemeal. The right infraorbital canal was damaged during surgery owing its close association with the mass. Recovery from anaesthesia was uneventful. The infraorbital nerve temporarily showed sensory deficits in the region of the muzzle and nose on the right. These deficits resolved 3 months post-surgery.

The mass was sectioned after decalcification. All sections stained with haematoxylin and eosin comprised mature, dense, lamellar bone with scattered multifocal irregularly-shaped spaces containing soft connective tissue that was principally adipose tissue. Some of the bony edges were lined by an indistinct single-cell layer of spindle cells, presumably osteoblasts. Two of the sections appeared to have on 1 edge a dense, narrow layer of fibrous connective tissue resembling periosteum. No osteoclasts were identified (Fig. 4).

Six weeks post-surgery follow-up radiographs revealed no mass in the right maxillary sinus, which was gas-filled, with increased soft tissue opacity in the rostro-ventral region. The bony septum of the maxillary sinus was visible caudally with an associated soft tissue thickening, but there was loss of definition of the extreme lateral part of the septum.

Unfortunately cases 1 and 2 were euthanased before further follow-up radiographs could be taken. In the 1st case the horse was euthanased almost 14 months post-surgery as a result of respiratory stridor and distress most likely originating from the paranasal sinuses. The 2nd case was euthanased almost 10 years later due to old age. The owner reported that this horse at no stage suffered from respiratory stridor or distress in the years following the surgery.

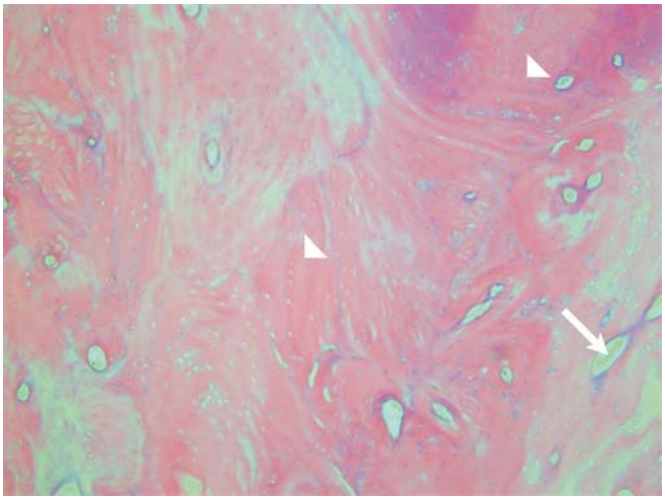

Fig. 2: **Case 1: osteoma comprising poorly-cellular compact woven bone** (arrowheads) **deposited around blood vessels of various sizes** (arrows). H&E stained, magnification ×40.

Case 3

A 14-year-old Historical Boerperd mare with suspected unilateral squamous cell carcinoma of the right 3rd eyelid and possible metastasis to the caudal maxillary sinus region was referred to OVAH for further diagnostics and therapy. Upon presentation the caudal border of the maxillary sinus in the region of the lateral canthus of the eye was thickened and displaced laterally. Percussion of the maxillary sinus was dull. The pink mass on the 3rd eyelid protruded above the level of the 3rd eyelid and the mare showed epiphora. The 3rd eyelid could not be everted. On palpation the mandibular lymphnodes were moderately enlarged.

Ophthalmic examination revealed what was thought to be a typical squamous cell carcinoma of the 3rd eyelid. No further diagnostic procedures on the eye were performed before surgery.

Radiographs of the paranasal sinuses including oblique views of the orbits revealed an oval soft tissue opacity (7 × 9 cm) in the ventro-medial region of the right maxillary sinus. The caudal margin of the mass was not well defined. Soft tissue

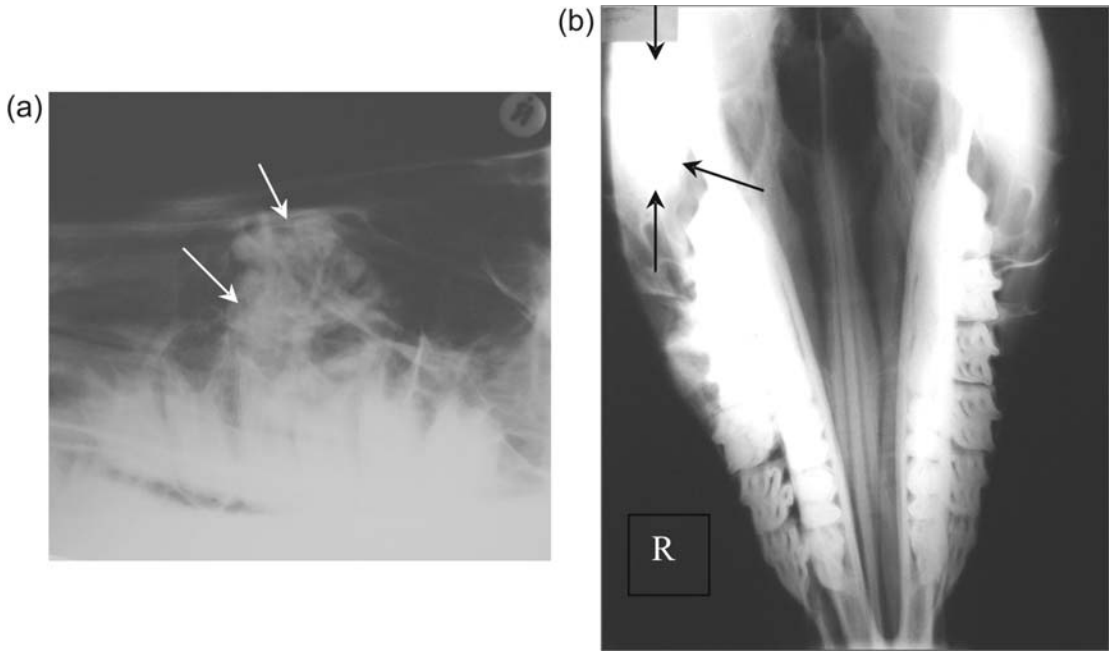

Fig. 3: a: **Case 2: right dorsolateral–left ventrolateral radiograph showing a non-homogenous, mineralised mass** (10 × 8 cm) **within the rostral maxillary sinus dorsal to premolar 4 and molar 1 and extending to the cortex of the overlying bone dorsally and laterally.** b: **Case 2: dorsoventral radiographic view showing bony mass extending lateral to right maxillary molar 1.**

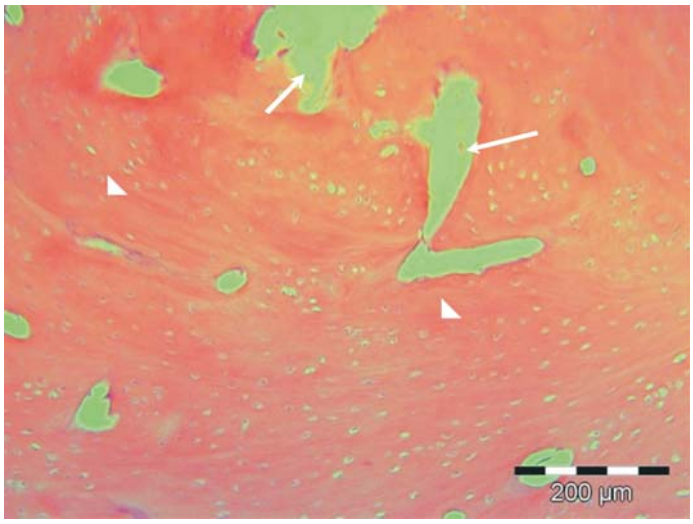

Fig. 4: **Case 2: compact bone osteoma** (H&E) **comprising dense lamellar bone** (arrowhead) **with irregularly-shaped spaces containing soft connective tissue** (arrows) **and occasionally lined by a single cell layer of osteoblasts.**

swelling in the right orbital region extending along the rostral aspect of the maxilla was visualised.

Endoscopy revealed no abnormalities of the nasal passages, pharynx, guttural pouches or laryngeal region.

Standing trephination of the right caudal maxillary sinus was performed under sedation (butorphanol and detomidine). A bony mass was visualised in the caudal aspect of the sinus. No purulent material was visible. The bony mass was soft and brittle in consistency and a biopsy was easily performed with rongeurs. The mare was administered phenylbutazone (2.2 mg/kg q12h initially i.v. followed by PO) following the procedure.

Histopathology of the bony mass biopsy using H&E staining revealed irregularly-shaped cancellous bone spicules interspersed among normal adipose tissue. Mulitfocal haemorrhages were seen within the adipose tissue. Other biopsied tissue revealed mature fibrous connective tissue containing intermittent blood vessels. Occasional scattered lymphocytes, plasma cells and neutrophils were seen. No overt signs of inflammation or neoplasia were present. Small chips of bone from the edge of the excised bony mass revealed no abnormalities.

The mare was scheduled for surgical removal of the mass. Routine pre-operative planning and protocols were followed before induction. The horse was induced and anaesthetised in a routine manner and placed in left lateral recumbency.

The mass involving the 3rd eyelid was more widespread than anticipated and involved the bony rim of the medial canthus of the eye, surrounding conjunctiva, medial sclera and *Muscularis rectus medialis* of the right eye. An enucleation was performed. Significant local infiltration of the soft tissue mass, as evidenced by granular abnormal tissue, was found all along the medial aspect of the *Muscularis retractor bulbi* ending close to the bone. This finding resulted in election for euthanasia.

The retrobulbar soft tissue expansile and infiltrative mass was a multinodular basal cell carcinoma exhibiting multifocal areas of necrosis, a predominantly papillary pattern and up to 6 mitotic figures per 40× field. Post-mortally, similar tissue nodules were found extending down into the maxillary sinus *via* the *fossa sacci lacrimalis* and irregularly covering the bony mass submucosally in the sinuses. The bony mass bridged the ventral frontal and cranial and caudal compartments of the right maxillary sinus, interfering with the infraorbital canal, and with its base extending along the bony roof of the hard palate (Figs 5a and 5b).

Histological examination of various areas after decalcification in formic acid confirmed the suspected diagnosis of osteoma. The mass consisted essentially of cancellous bone and was lined peripherally by layered fibrous periosteal connective tissue. The adipose tissue filling the spaces between the irregularly-shaped internal mineralised bone spicules was well-supplied with blood vessels with occasional small perivascular aggregations of lymphocytes and plasma cells, and there was no haematopoietic tissue. The bone spicules consisted of mature lamellar bone intermittently lined by a single layer of osteoblasts that appeared more prominent and plump around the peripheral subperiosteal spicules, which were often aligned more perpendicularly with the periosteum. No osteoclasts were found in the sections examined (Fig. 6a,b,c).

Case 4

A 15-month-old Arabian colt was referred with a persistent chronic purulent right

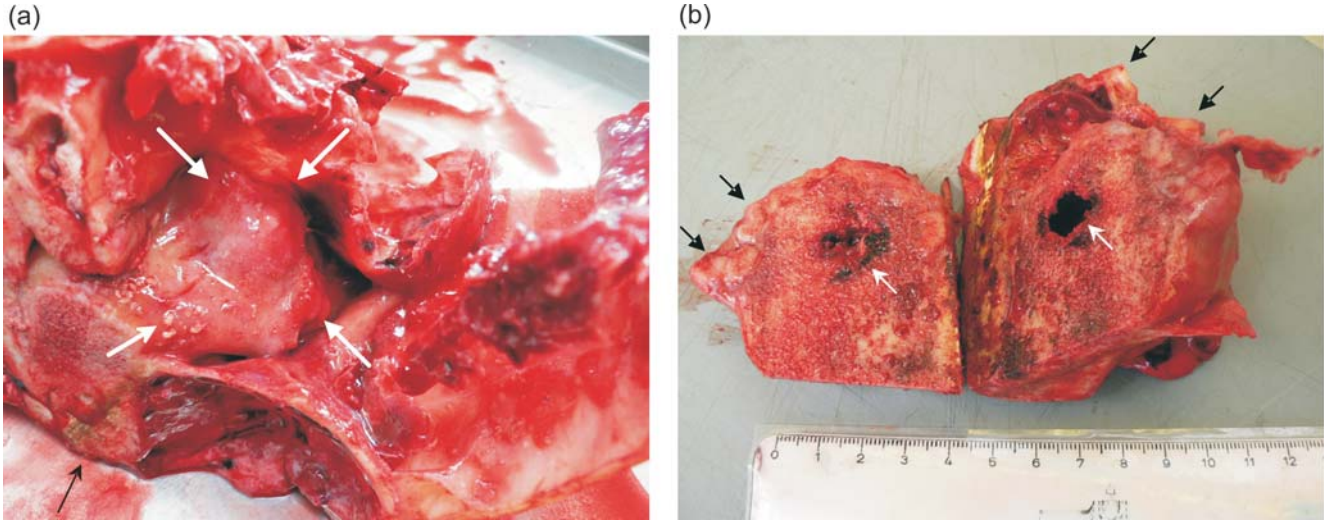

Fig. 5: a: **Case 3: osteoma** (white arrows) **below infraorbital canal with hard palate in left ventral quadrant** (black arrow). b: **Case 3: osteoma sawn open to reveal well-demarcated cancellous bone with central cavity tissue removed** (the prior biopsy site) (white arrows)**. Basal cell carcinoma soft tissue nodules around periphery** (black arrows)**.**

nasal discharge of approximately 4 months' duration. Owing to the development of severe, acute respiratory distress an emergency tracheotomy was performed.

Upon presentation the foal appeared bright, alert and responsive, with a unilateral purulent nasal discharge from the right. A mild mucoid left nasal discharge was also noted. The submandibular and retropharyngeal lymphnodes were enlarged.

Radiographic examination of the paranasal sinuses using routine views including views of the pharyngeal region revealed a 14 × 15 × 8 cm soft tissue opacity within the right nasal passage area extending from the right ethmoid area and causing marked left displacement of the nasal septum and obliteration of the right common nasal meatus (Figs 7a and 7b). The mass had a slightly bilobed appearance on the right lateral view, extending into the concho-sinus area. There was moderate soft tissue opacity of the right caudal and rostral maxillary sinus. On the lateral view an irregularly marginated soft tissue swelling up to 5 mm thick extended for 17 cm along the frontal and nasal bones. Both the thickened bone and the soft tissue swelling extended to the left and right dorsolateral aspects of the skull. The dorsal roof of the pharynx was thickened up to 12 mm. The caudal aspect of the Eustachian tube diverticulum (guttural pouch) was indented caudoventrally by at least 2 soft tissue bulges, which were thought to represent lymphadenopathy, either reactive or metastatic. The soft palate was displaced dorsally to the epiglottis.

Endoscopy was performed under sedation (xylazine, 0.5 mg/kg i.v.). A pale pink, smooth mass obstructing the left ventral meatus prevented the endoscope from being passed further. Endoscopy of the right ventral meatus identified a similar but larger mass completely occluding the right nasal passage. Endoscopy *via* the tracheotomy site revealed the same mass protruding into the pharynx. An aspirate *via* the endoscope yielded a sample of straw coloured, turbid fluid from the mass in the left nasal passage. The mass was subsequently drained enabling visualisation of the pharynx and left guttural pouch. Examination of the pharynx revealed a small cyst-like structure protruding from the left side below the epiglottis. Endoscopy of the guttural pouches did not reveal any abnormalities. An attempt to aspirate a fluid sample from the mass in the right nasal passage led to profuse haemorrhage that curtailed further diagnostic attempts.

Cytology of the right caudal pharyngeal aspirate revealed a modified transudate with a specific gravity (SG) of 1.045 and nucleated cell count of $0.4 \times 10^9/$, with most of the cells caught up in a small fibrin clot. Some neutrophils, macrophages, a few nasal epithelial cells and some goblet cells were seen. Two groups of anaplastic epithelial-type cells were noticed showing basophilic cytoplasm and coarse nuclear chromatin, with prominent and multiple nucleoli.

A decision to surgically remove the mass was made owing to respiratory distress. Routine pre-operative planning and protocols were followed before trephination of the right maxillary sinus

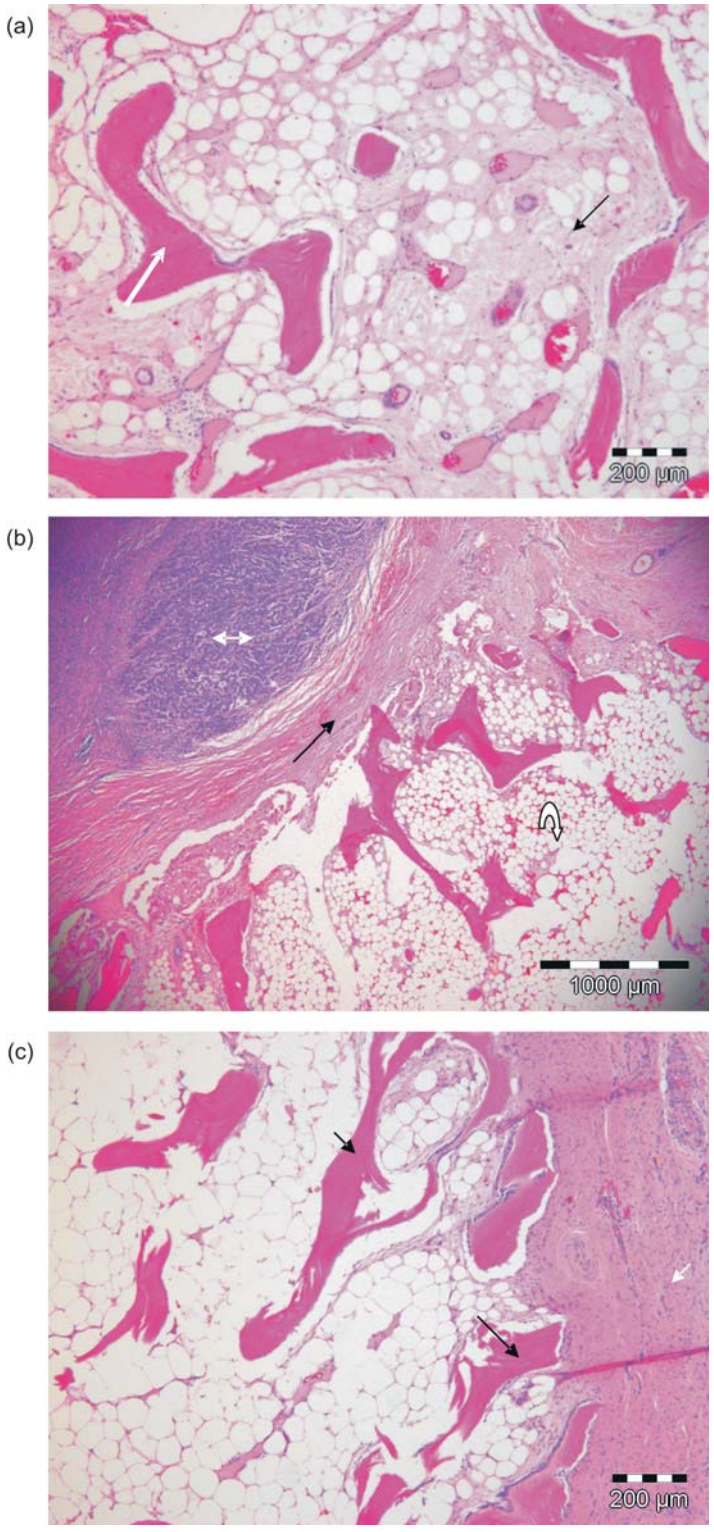

Fig. 6: a: **Case 3: osteoma histopathology** (H&E) **showing central cancellous bone spicules** (white arrow) **within adipose and vascularised connective tissue** (black arrow). b: **Case 3: osteoma** (right in histological H&E image / curved arrow) **with basal cell carcinoma nodule** (double-ended arrow) **causing pressure on the outer periosteal lining** (arrow). c: **Case 3: periphery of osteoma showing more perpendicularly-arranged bone spicules** (black arrows) **below the periosteum to the right of image** (white arrow).

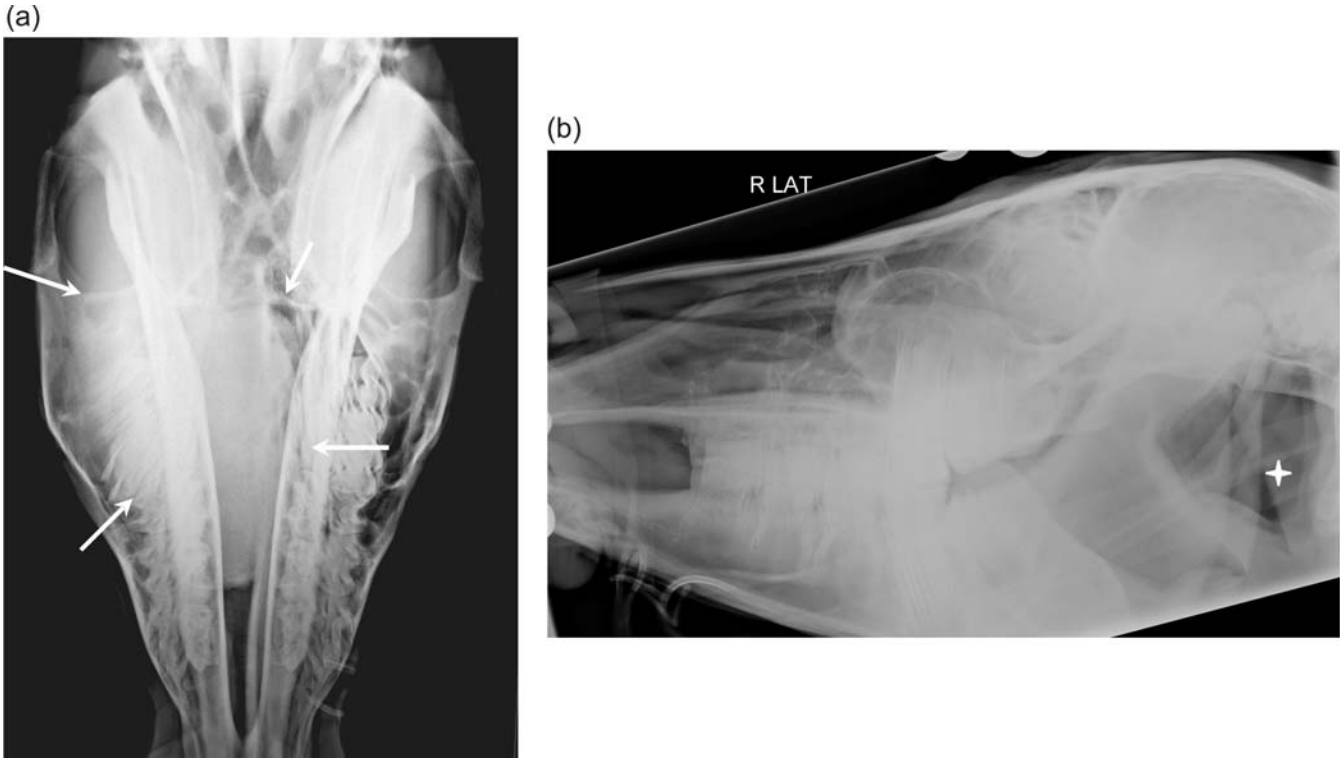

Fig. 7: a: **Case 4: dorsoventral radiographic view showing soft tissue mass extending from right maxillary sinus into right ventral conchal sinus obliterating the right common nasal meatus and displacing the nasal septum to the left. Right is to the left of the image.** b: **Case 4: left to right lateral radiograph showing the bilobed soft tissue mass occupying the maxillary sinus and extending into the conchofrontal sinus. There is soft tissue swelling dorsal to the frontal and nasal bones and caudal indentation of the Eustachian tube diverticulum by soft tissue masses** (cross).

followed by enlargement of the trephination site under general anaesthesia.

The right caudal maxillary sinus was trephined in the standing, sedated colt. A large soft tissue mass was palpable within the maxillary sinus. Biopsy of the mass revealed yellowish-brown, hard, cartilage-like tissue. General anaesthesia was then performed to facilitate its removal. The horse was induced and anaesthetised as described previously and placed in left lateral recumbency. The trephination site was enlarged and 85 % of the mass within the maxillary sinus was removed. The bony septum between the caudal and rostral maxillary sinuses had been obliterated by the mass. Samples of the mass were preserved in 10 % formalin for histopathology and also submitted on ice along with a swab of purulent discharge from within the maxillary sinus for bacterial culture and antibiogram. After partial mass removal moderate haemorrhage occurred and 6 of fresh blood were transfused into the patient. When it was realised that the entire mass could not be removed, surgery was aborted and a pre-loaded stockinette was placed in the sinus as a packing to provide haemostasis as described in the 1st case.

After the patient had recovered uneventfully the tracheostomy tube was replaced. Postoperative medications initially included procaine penicillin G (22 mg/kg IM q12h) and phenylbutazone (2.2 mg/kg PO q12h). The stent was gradually removed over a period of a week. *Streptococcus equi* var *zooepidemicus* was isolated in pure culture from the fluid aspirated directly from the mass during the initial endoscopic examination. This bacterium was sensitive to all antibiotics tested. *Streptococcus equi* var. *equi* was isolated in pure culture and showed abundant growth from the samples of the mass and surrounding mucopurulent discharge obtained during surgery. The antibiogram showed intermediate sensitivity to trimethoprim sulphonamides and resistance to penicillin G.

Histopathology using H&E stain was similar in all the samples. Irregularly-shaped spicules of osteoid and bone were randomly arranged in a moderately vascularised fibro-osseous stroma. Some areas showed numerous osteoclasts and little osteoid. The mass was diagnosed as an osseous fibroma[10] (Figs 8 & 9).

After removal of the nasal stent, endos-

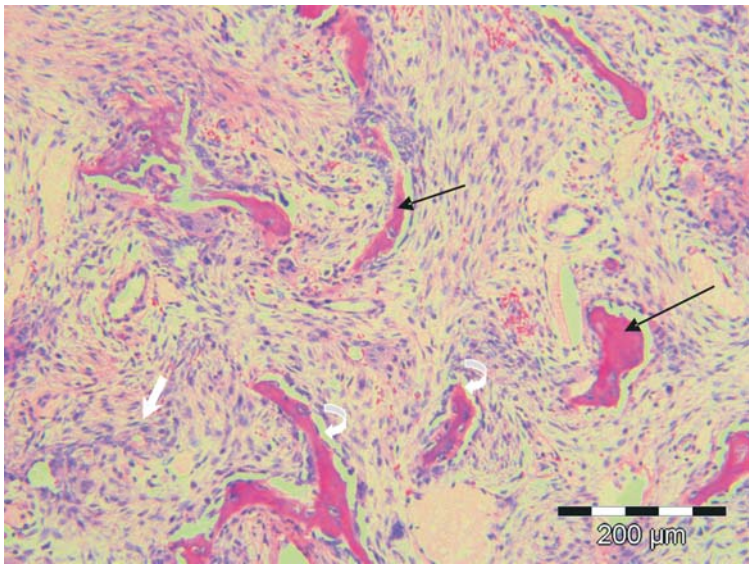

Fig. 8: **Case 4: H&E section of osseous fibroma showing irregular bone spicules** (black arrows) **lined by osteoblasts** (curved arrow) **embedded in dense fibrous connective tissue** (white arrow)**.**

copy of the nasal passages performed under sedation (detomidine and butorphanol) revealed the presence of similar masses as observed before surgery. The right maxillary sinus was flushed and initially a mucohaemorrhagic discharge was seen.

Postoperative radiographs revealed a slight decrease in the size of the soft tissue opacity in the right caudal maxilla and frontal sinus, with displacement of the nasal septum and obliteration of the right common nasal meatus unchanged.

The owner opted to euthanase his horse owing to a poor prognosis for complete recovery.

After euthanasia the head was removed and evaluated further by computed tomography (CT) (Siemens Somaton Sensation. 16 Slice, Siemens AG, Medical solutions, Siemensstr. 1, D-91301 Forchheim, Germany). Bone and soft tissue 3-D reconstructions of the affected area were made showing a non-homogenous soft tissue density (Hounsfield units of 47–79) within the right maxillary sinus extending into the frontal sinus and the right ventral conchal sinus causing various degrees of bony destruction of the frontal bone, cribiform plate and hard palate and displacing and exerting pressure on maxillary premolars (Fig. 10 a,b,c).

DISCUSSION

Paranasal sinus tumours are relatively uncommon in horses[6,26] and tumours of the bone in general are reportedly uncommon in the horse[6,13,15,24]. An osteoma is classified as a smoothly contoured[6], protruding lobulated mass of abnormally dense but otherwise normal bone originating from the periosteal surface of

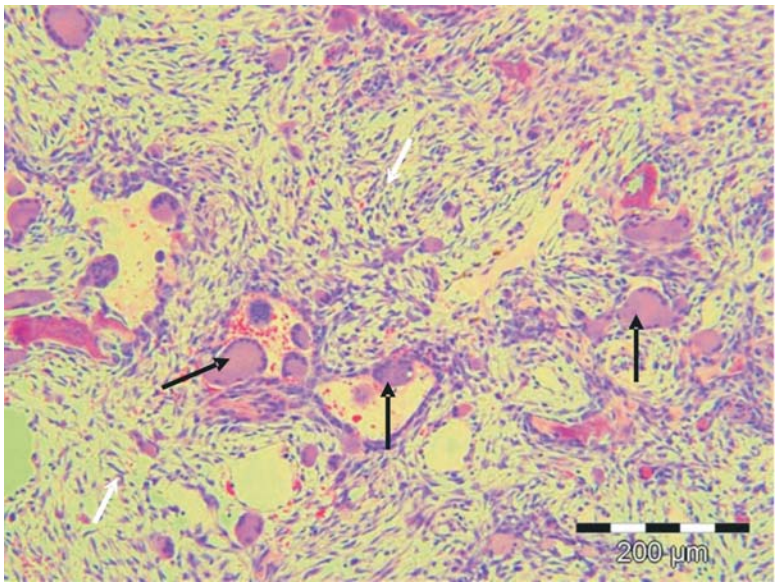

Fig. 9: **Case 4: osseous fibroma showing areas of fairly densely cellular fibrous connective tissue** (white arrow) **with numerous osteoclasts** (black arrows) **and devoid of osteoid.**

Fig.10: a: **Case 4: CT of dorsal bone window of head showing well-marginated mass** (arrows) **in right nasal passage** (left in image) **with destruction of caudal aspect of nasal septum and extension of the mass into the choanae. Gas densities around mandibles are due to *post-mortal* gas dissection into tissues.** b: **Case 4: transverse bone window CT of head showing soft tissue density mass** (white arrows) **in right nasal passage and right maxilla and focal destruction of the affected maxillary bone and alveolus with displacement and malformation of the affected premolar. The extreme lateral aspect of the mass is missing due to partial surgical removal and the metallic density wire** (black arrow) **can be seen at the lateral aspect of the maxillary nasal flap. Right is to the left of the image.** c: **Case 4: right parasagittal bone window** (CT) **illustrating rostrocaudal extent of the soft tissue density with loss of bone density in the vicinity of the cribriform plate** (arrow)**. Gas densities in the cranial cavity are due to *post-mortal* gas dissection into tissues.**

bones, usually those that form by intramembranous ossification[12,23]. The site of origin or attachment of the osteoma within the maxillary sinus is often difficult to determine[19]. Osteoma may be closely associated with the 1st molar tooth[1,7,12] and in 1 report the osteoma was attached to the ventral surface of the lachrymal bone[21]. An osteoma is a benign, slow-growing tumour of bone[6] that may demonstrate progressive growth over a period of months and then become quiescent for years[23]. Osteomas are expansile and are not infiltrative. They are typically found in the paranasal sinuses of horses, particularly the maxillary sinus[4,6].

Osseous fibromas in humans are presumed to originate from mesenchymal blast cells that exist in the periodontium surrounding the teeth[3]. Osseous fibromas show a predilection for the jaw[17], but may occur in any of the membranous bones of the skull[3,11,13]. Mandibular osseous fibromas are expansile and replace normal bone tissue with fibro-osseous stroma[17,23]. Mandibular osseous fibroma is reported to be a syndrome of horses less than 1 year of age[11,22,17]. It has been suggested that osseous fibromas may be associated with trauma[11], but the young age observed in affected human individuals and horses suggests that this lesion is probably developmental in origin[22].

Most osteomas are found in young horses from 6 weeks to 2 years of age[4,11,14,21], but have been reported to be present at birth[6,21]. The cases reported here involved an 8-year-old Thoroughbred mare; a 9-year-old Warmblood gelding; a 15-month-old Arabian colt and a 14-year-old Historical Boerperd mare. Too few cases of osteoma are documented to permit proper evaluation of the influence of age, breed or sex[23]. Horses are usually presented as a result of typical clinical signs including facial deformity or asymmetry, unilateral nasal discharge and respiratory stridor due to obstruction of airflow through the nasal passage. The symptoms are caused by the expansile nature of the osteoma[6], but these tumours are slow-growing and can expand within the complex anatomical space of the sinuses with clinical signs only becoming evident much later in life[19] even though the tumour may have been present shortly after birth.

A presumptive diagnosis of an osteoma or osseous fibroma is based on clinical examination, endoscopy, radiography and even computed tomographic evaluation[1] of the paranasal sinuses. A definitive diagnosis is based on histopathology. Histopathological differentiation of certain benign neoplasms and inflammatory lesions may be difficult[24].

Osteomas are composed of dense accumulations of well-differentiated cancellous or compact bone with delicate intervening fibrous and vascular tissue[6,23]. Head *et al.* reported that when actively growing, the woven bone spicules at the periphery are aligned perpendicular to the surface and later become lamellar bone[6]. With growth, the intervening stroma shrinks and may be replaced by fat or even haematopoietic marrow. The spicules fuse to form cortical compact bone. Well-developed Haversian systems can be identified as the remodelling proceeds.

The same authors also described fibrous dysplasia as smooth-surfaced lesions which are soft and gritty and may contain blood-filled cysts[6]. The bulk of the lesion is formed by highly cellular, fibrovascular tissue containing few mitotic figures. Poorly mineralised, thin woven osteoid or poorly differentiated bone spicules are found throughout the stroma. These spicules form by metaplasia from the spindle-shaped fibroblasts and therefore, unlike osteoma, do not exhibit a row of osteoblasts on their border[6,8,23]. Other differential features are the absence of orientation of the spicules and of the cortical bone. Osteoclasts may be present reabsorbing the surrounding bone at the edge of the lesion. Multinucleate giant cells may also be found in the stroma associated with areas of cystic degeneration and haemorrhage.

Head *et al.*[6] reported that a chronic osseous or ossifying fibroma has the features of both osteoma and fibrous dysplasia. As well as osteoid, there is prominent osteoblastic rimming of the osteoid spicules[8,11]. Cases have been recorded in the equine mandible[8,11,13].

Some osteomas have features common to all 3 entities, which suggests the possibility that osteoma may be an end stage of more than one process[15,23].

Osteomas are usually amenable to surgical excision[14,25,26,28] because they usually have a small sessile or pedunculated[4,26] attachment and may be movable[19]. Small osteomas have reportedly been removed *via* a frontonasal flap while the patient was standing[21]. Owing to the complex communicative anatomy of the paranasal sinuses, advanced osteomas are often difficult to remove surgically[4] even after fragmention[14,19] without causing severe damage to the surrounding bone, leading to either partial removal or euthanasia. Access to the paranasal sinuses can be gained through a large frontonasal bone flap[2,5,18,28] or a bone flap created directly over the maxillary sinus. Better exposure to multiple sites is gained with the frontonasal flap[2,16,26]. The maxillary flap is not ideal in young animals because there is limited access as a result of the long reserve crowns, dental apices of the cheek teeth and infraorbital canal[5,16]. Most of the cases described in this report confirm the difficulty of entire removal of extensive osteomas from the complex paranasal sinuses. In the single case in which the osteoma was totally removed the tumour had a pedunculated attachment and showed no signs of recurrence over a 10-year period.

Little information is available on the progression and clinical management of tumours in the paranasal sinus region and inconsistencies exist regarding re-growth of lesions after complete[18] and incomplete removal. In one study only 12 % of horses with sinonasal neoplasia reported long term post-surgical remission of clinical signs[25]. Other studies reported that osteomas may recur locally following incomplete surgical removal[23,27]. Osseous fibromas frequently recur if incompletely excised[11,13,17]; adjunctive radiotherapy[2,17] may delay or prevent tumour recurrence[13,17]. Complete resection[3,13] of the mass or rostral mandibulectomies[11] have been described.

Radiotherapy uses ionising radiation to treat solid tumours. Dose-specific radiation treatment of an area is performed, sparing the surrounding tissue. Tumour destruction results from deposition of energy in the cells, which causes damage to the cellular DNA, so that the cell is unable to divide and dies. Normal tissue is also affected by radiation energy, but it is more capable of repairing radiation damage than is tumour tissue[13].

Because osseous fibromas have a tendency to recur, frequent (2-monthly)[13] follow-up evaluations including endoscopy and radiography are advised to monitor any re-growth.

In the 2 cases reported here that went home post-surgically, follow-up radiographs were not performed. If the surgeon is not satisfied that mass removal was sufficient, close follow-up of the case is recommended.

Computed tomography can help with surgical planning and prognostication by more clearly demonstrating the size of the tumour and extent of involvement of other structures, and has the advantage of no superimposition of structures as is seen with radiography[1,10,20]. Unfortunately CT requires specialised equipment and general anaesthesia and is costly. The time required to position a horse within the CT unit and perform scanning has been reported to be an hour or more[1]. This may necessitate a 2nd general anaesthetic if surgery is to be performed.

CONCLUSION

The authors are of the opinion that osteomas and ossifying fibromas are probably not as uncommon as was previously thought but are rather infrequently diagnosed because the clinical signs may only become apparent when the bony growth eventually becomes large enough to cause distortion or occlusion of the paranasal sinuses. With the use of improved diagnostic modalites such as computed tomography, the extent of the bony masses as well as the involvement of structures within their close proximity may be gauged, thereby determining the feasilbility of the surgical procedure. They may also not be as readily removable as previously supposed. However, more cases need to be reviewed to come to a more reliable conclusion on this matter. In order to ascertain whether osseous fibromas are an early stage of osteomas, such cases would need to be monitored during their development.

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