

# Complications of Equine Cheek Teeth Extractions

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October 27, 2022

## Abstract

Due to the length of the reserve crown and roots of equine cheek teeth, especially in younger horses, their extraction (exodontia) can be a challenging procedure with the potential for many types of post-extraction complications to develop. The prevalence of post-extraction complications is greatly influenced by the exodontia technique used, with unacceptably high levels of complications with the traditional repulsion technique and conversely, low levels of complications with oral extraction performed by skilled operators. Recent objective studies on post-exodontia problems in horses have also highlighted some risk factors for the development of post-extraction problems including exodontia of rostral mandibular teeth in young horses, and exodontia of teeth with apical infections. The recent recognition that some non-healing post-extraction equine alveoli suffer from a disorder very similar to dry socket in humans, may help clinicians to recognise, treat and possibly help prevent this disorder.

## Complications of Equine Cheek Teeth Extractions

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### Introduction

Historical aspects of equine cheek teeth exodontia techniques and extraction complications

The type and prevalence of equine post dental extraction problems are closely related to the dental extraction (exodontia) technique used as reviewed by Dixon *et al.* (2009), Earley *et al.* (2013), Carmello *et al.* (2020), Kennedy *et al.* (2020) and Reardon (2022). Oral extraction in conscious, cast horses restrained by ropes, or under chloroform anaesthesia, or occasionally in standing horses restrained by twitches and leg ropes were widely practiced in the 1800s and early 1900s with obvious welfare problems in non-anaesthetised horses (Easley 2022). Nevertheless, many excellent equine oral extraction instruments and oral speculums were developed at those times. In the mid-1900s, for reasons unknown to the author, the practice of cheek teeth repulsion under chloroform and later, halothane general anaesthesia largely replaced oral extraction and became the standard equine cheek teeth exodontia technique (**Fig 1**). The repulsion technique, with its very high reported complication rate of up to 67% (Dixon *et al.* 2000) or 80% (Carmello *et al.* 2019) remained the standard cheek tooth exodontia technique until the 1990s.

The use of the (standard) lateral buccotomy cheek teeth exodontia technique in the late 1900s caused a reduced prevalence but a different range of post-operative complications (O'Neill *et al.* 2011), as well as always requiring general anaesthesia with its attendant costs and risks. The advent of effective and safe equine sedation drugs facilitated the (re)introduction of standing oral extraction in the 1990s (Dixon *et al.* 2005; Tremaine 2010) using similar oral speculums and extraction instruments developed over 100 years previously. The later introduction of effective regional local anaesthetic techniques (Tremaine, 2007) further enhanced oral extraction techniques, that remains the current equine exodontia technique of choice.

However, oral exodontia requires the presence of a sufficiently strong clinical crown on the affected tooth. The development of less invasive exodontia techniques for teeth with incomplete clinical crowns, including minimally invasive (Steinmann pin) repulsion, minimally invasive transbuccal technique (MITT) (also termed

minimally-invasive transbuccal extraction [MTE]) and intra-oral dental sectioning have reduced the prevalence of post-extraction problems of teeth with an incomplete clinical crown as compared to the standard repulsion technique (Langeneckert *et al.* 2015; Kennedy *et al.* 2020; Carmello *et al.* 2020). Regardless of the exodontia technique that is used, post-extraction problems can still occur even following careful extractions by skilled veterinarians (Kennedy *et al.* 2020; Geigert and Bienert 2020).

### Post-extraction alveolar management

Apical infection (**Fig 2**) is the most common indication for cheek teeth exodontia, being the reason for 62% of 428 extractions in a recent study (Kennedy *et al.* 2020). Exodontia of apically infected teeth causes a bacteraemia with potential pathogens, including anaerobes (Kern *et al.* 2017). Many clinicians administer pre-operative antibiotics (e.g., penicillin and an aminoglycoside) including to help prevent the rare spread of bacteria from infected teeth to distant sites, that can cause infections such as meningitis (Bach *et al.* 2014; Arndt *et al.* 2021). When infection of the supporting bones is present, longer-term post-extraction antibiotic therapy is justified. There is less consensus on the routine use of post-extraction antibiotic therapy in other exodontia cases.

Following exodontia, the alveolus should be digitally and visually (using a dental mirror or oral endoscope) examined, as should the apical aspect of the extracted tooth to ensure that no dental fragments remain in the alveolus. If any doubt remains, and always following repulsion techniques or where the apex of the tooth is not intact, post extraction radiography should be performed to ensure that no intra-alveolar dental (or alveolar bone fragments) remain. Any such identified fragments should be immediately removed digitally or using long, right-angled equine dental picks with adjustable heads under visual guidance, and with use of suction of intra-alveolar blood to allow visualisation of mandibular alveoli. If suitable picks are unavailable, high pressure lavage of the alveolus using an equine dental syringe may remove unattached bone or dental fragments. Formation of a new blood clot should now be encouraged, if necessary, by alveolar curettage.

Optimal post-extraction healing will occur in an alveolus that did not have significant pre-existing alveolar bone infection, which has not sustained excessive exodontia-related alveolar bone damage, does not contain dental or bone fragments and which contains a large post-extraction blood clot. The alveolar blood clot should be protected from masticatory forces and food impaction by placing packing material (e.g., polysiloxane, acrylic or surgical swabs [gauze] impregnated with antibiotics, honey or dilute antiseptics) in the more occlusal (e.g., one third) aspect of the alveolus. Excessively deep alveolar packing will mechanically reduce or even prevent alveolar healing. Some clinicians have used antibiotic-impregnated surgical swabs in the more occlusal half of the alveolus to help treat existing and help control post-operative alveolar bone infection (Kennedy *et al.* 2020). The risk of bacterial antibiotic resistance development must be considered with such local antibiotic therapy. The use of surgical swabs soaked in concentrated antiseptic solutions such as Povidine iodine may risk causing chemical irritation and delayed alveolar healing.

No large objective studies have determined which post-extraction alveolar management is optimal. However, anecdotal evidence indicates that just placing packing material in the alveolus following exodontia and allowing this material to spontaneously dislodge later, is unsatisfactory. This is especially true following exodontia of apically infected Triadan 06-08 mandibular cheek teeth in younger horses (Kennedy *et al.* 2020; Geigert and Bienert 2021). Instead, the post-extraction alveolus should be actively managed until healing is complete or near complete. The alveolar packing inserted immediately post extraction should be removed about 7-10 days later, and the alveolus digitally examined to assess if it is lined by smooth (developing granulation) tissue over all its surfaces. Rough areas of exposed bone such as caused by alveolar sequestration or *dry socket* are readily palpated and if these bony areas are loose (i.e. are sequestrae rather than dry socket), they should be removed digitally or using picks.

If the alveolus appears to be healing normally at this first re-examination, it should be gently lavaged, without dislodging the blood clot. The occlusal aspect of the alveolus should be repacked (using less packing material on this occasion) and the alveolus re-examined 1- 2 weeks later to further assess alveolar healing and in particular, for evidence of delayed sequestration. As noted, the most rigorous management is needed

following extraction of younger mandibular teeth with apical infection and such cases should have repeated alveolar examinations until healing is very advanced.

## Post-extraction disorders

### Damage to adjacent teeth

Due the normal angulations and curvatures of the cheek teeth reserve crowns in the rostro-caudal plane, and/or due to improper repulsion punch placement, the punch may damage adjacent teeth (Dixon *et al.* 2000), unless its position and angulation in the *rostro-caudal plane* is carefully monitored by intra-operative radiography during repulsion. Damage to adjacent teeth can less commonly occur during sectioning of teeth with damaged clinical crowns or during dental luxation using an elevator and mallet when using the MITT. If the apical blood supply of adjacent teeth is iatrogenically damaged, this will cause death of the tooth.

### Traumatic alveolar damage

Movement of the punch in a *medial or lateral plane* during repulsion may markedly damage the alveolus and supporting bones. When repulsing a mandibular cheek tooth, the punch may penetrate or even fracture the mandible, lingually or buccally to the tooth. Similarly, when repulsing a maxillary cheek tooth, the punch may penetrate or fracture the hard palate or the buccal aspect of the adjacent maxillary bone. Such damage can predispose to sequestration and/or local soft tissue infection.

Due to the angulation of the caudal cheek teeth reserve crowns and the presence of the facial crest, it is not possible to perform the MITT extraction on all cheek teeth positions. Additionally, when teeth are being elevated (loosened) with a transbuccal elevator and mallet, the elevator will always cause local alveolar bone damage. Additionally, the angle of introduction of the elevator into the alveolar spaces is not always optimal and can cause local alveolar bone damage due to the restriction of using a single cannula site.

The use of partial crown removal (partial coronectomy) to facilitate mesio-distal (rostro-caudal) dental crown movement when using cheek teeth separators (Rice and Henry, 2018) or full sectioning of teeth with damaged clinical crowns, dilacerated roots or apical hypercementosis also carries a risk of causing direct traumatic or thermal (if using non-water cooled equipment) alveolar bone damage. This can cause delayed sequestration and infection of the injured bone.

### Retention of dental fragments

Standard repulsion of apically infected teeth tends to drive the punch into the diseased (less mineralised) apex and adjacent reserve crown and can cause peripheral fragments of the reserve crown to fracture off and remain attached to the alveolar wall (**Fig 1**). These fragments need to be identified (including by routine post-extraction clinical and radiographic examinations following repulsion) and removed, else they will likely result in a non-healing alveolus. Dental fragments, except for long mandibular roots in older horses (**Fig 3**) are less commonly retained following other exodontia techniques

### Damage to facial nerves, vasculature and parotid duct

The standard lateral buccotomy extraction technique has largely been discontinued due to its invasive nature, necessitating long incisions in the cheeks and/or supporting bones with risk of damaging buccal nerve branches, facial vasculature or the parotid salivary duct and always requiring general anaesthesia. There is a low risk of such damage with a carefully performed MITT.

### Infraorbital Nerve Damage

Damage to the infra-orbital canal and its nerve can occur during maxillary cheek tooth repulsion, especially in young horses where the infra-orbital canal sits immediately medio-dorsal, or dorsal to the apical aspect of the alveolus. In many young horses, it is difficult to understand how such nerve damage is avoided during a standard repulsion. If the infraorbital nerve is damaged by repulsion techniques, clinical signs may occur within hours in a proportion of horses, and can include violent headshaking, distress, and rubbing (even excoriating) the ipsilateral nostril off adjacent structures. Such cases usually do not respond to corticosteroid,

non-steroidal anti-inflammatory, or opiate therapy, but may respond in the short-term to acetylpromazine therapy. Thankfully most cases show spontaneous resolution of clinical signs within 1 to 2 weeks of nerve injury. However, some cases of trigeminal damage can cause longer term headshaking (Ogden *et al.* 2022). Infraorbital nerve damage is much less likely following Steinmann pin repulsion, but long term signs of clinical trigeminal neuropathy can rarely occur following use of this technique.

### **Surgical site infection**

Due to their inevitable contamination, infection of trephine repulsion sites is common but usually self-limiting. Prolonged non-healing of cutaneous repulsion tracts should prompt an examination for the presence of intra-alveolar dental or bone fragments, or of saliva or food from oral leakage. Local infection and delayed healing can occur at standard buccotomy wounds (O'Neill *et al.* 2011) but rarely at MITT sites.

### **Sequestration of alveolar wall**

The most common complication following oral extraction is sequestration of segments of alveolar bone with or without concurrent alveolar infection. Kennedy *et al.* (2020) found alveolar sequestration to be the most common post-extraction problem and was identified in 38/428 cheek teeth extractions (including 343 oral extractions). Clinical signs of alveolar disease were present in 17 of these cases (4% of 428 cases) but in 15 cases (3.5%) the (usually smaller) sequestrae that were detected on routine post-extraction alveolar examinations did not cause a detectable clinical problem (Kennedy *et al.* 2020). Giegert and Bienert (2021) found a 6.6% (20/302 cases) prevalence of clinical post-extraction complication with mandibular cheek teeth oral extractions, with 18 of 20 complications being alveolar sequestration and infection, including sequestration of the complete alveolar wall.

Due to the great length (up to 9cm long) of equine cheek teeth reserve crowns, high and prolonged mechanical forces are required to break down their periodontal membranes. High forces are also required to deform the layer of dense bone (i.e., bundle bone or cribriform plate – radiologically termed the *lamina dura [denta]* ) that lines the alveolus and compress it into the underlying spongy bone to enlarge the periodontal space and so allow dental movement and later extraction (**Fig 4** ). This necessary alveolar bone deformation can cause it to fracture deeply and/or may disrupt its local blood supply. The partial coronectomy technique (Rice and Henry, 2018) may less traumatically create additional intra-alveolar space to facilitate extraction.

Fragments of fractured alveolar bone may be detected immediately following exodontia if the fractured bone segment is displaced by exodontia forces. More commonly, alveolar fragments are recognised a week or more later (**Fig 5** ), especially if caused by extraction-induced loss of blood supply to a local area of fractured alveolar bone. The presence of alveolar sequestrae prevents alveolar healing and can acts as a nidus of infection, often leading to alveolar infection and even osteomyelitis of the supporting bones (**Fig 6** ). Such infected alveoli are usually malodorous and on digital palpation have areas of exposed bone and contain loose sequestrae. Alveolar sequestration occurs more commonly in mandibular as compared to maxillary cheek teeth, as is also the case in human dentistry (Chiapasco *et al.* (1993), possibly related to differences in the thickness and rigidity of these bones and their blood supply. The effects of gravity in retaining alveolar bone sequestrae and infected exudate in mandibular as compared to maxillary alveoli may also be significant.

### **Alveolar bone infection and osteomyelitis of the supporting bones**

The most common indication for equine cheek teeth exodontia is infection of the tooth apex that is usually caused by mixed anaerobic bacterial infections (with concurrent infection of some or all pulp horns, the adjacent periodontal membranes and alveolar bone). Extraction-related damage to the alveolar bone may allow more extensive bone infection by these pathogens to develop. Consequently, post-extraction complications are higher following extractions of apically infected as compared to fractured teeth without clinical apical infection (Kennedy *et al.*2020) and especially in horses with pars pituitary intermedia dysfunction. Concurrent alveolar sequestration is common with alveolar and supporting bone infections and it may not be possible to determine which came first (**Fig 6** ).

If the supporting mandibular or maxillary bones are swollen and painful on palpation, the alveolus is obvi-



ously infected and will usually contain malodorous exudate. Systemic and possibly local antibiotic therapy should be administered to such cases along with removal of sequestrae and alveolar lavage. Repeat examinations, even weeks later may show development of new sequestrae that also must be removed. Because many of the bacteria involved in dental infections are partial or full anaerobes and possibly 50% cannot be conventionally cultured, broad-spectrum antimicrobial treatment that is effective for anaerobic infections should be administered to such cases. Further examinations including imaging to assess the degree of bone infection and detect new sequestrae should be performed until the alveolus has complete granulation tissue cover indicating alveolar healing (**Fig 7** ).

### **Oro-maxillary, oro-nasal and oro-cutaneous fistulae formation**

The presence of a food-containing nasal discharge following exodontia is indicative of an oro-nasal (**Fig 8** ) or oro-maxillary (**Fig 9** ) communication and likewise the presence of food at a repulsion site indicates the presence of an oro-cutaneous communication. By necessity, repulsion always damages the apical aspect of the alveolus and if the alveolar packing is lost before the damaged alveolar apex has healed, this causes oro-maxillary, oro-nasal or oro-cutaneous tracts that eventually may epithelialise and become fistulae. This is in total contrast to non-repulsion techniques that preserve the alveolus. Damage to the alveolar apex is especially marked when a traditional (large) dental punch is used, and one study showed an 11% prevalence of oro-maxillary or oro-nasal fistulation following repulsion (Carmello *et al.* 2020). In contrast, the careful use of a fine punch (e.g., a 5mm diameter Steinmann pin) seldom causes fistulae, especially if inserted through a pre-existing apical draining tract.

When loosening maxillary cheek teeth using the MITT technique, care must be taken that the dental elevator is not punched too far in an apical direction, or at a later stage of MITT, that the drill bit does not penetrate the apex of the alveolus into the overlying sinus or nasal cavity. Greatly varying prevalences of oro-maxillary fistulae have been reported following MITT from 29% (Carmello *et al.* 2020), 26% (Reichert *et al.* 2014) to 2% Langeneckert *et al.* 2015).

For treatment, these tracts need to be lavaged of food and debrided of any epithelial lining. A more robust barrier e.g., an acrylic alveolar prosthesis, can be placed between adjacent teeth to prevent further alveolar food ingress into the alveolus until it heals (Dixon, 2020).

### **Non-healing alveolus with exposed alveolar bone (“Dry socket”)**

The presence in non-healing alveolus of exposed, often tan-coloured, alveolar bone that *remains firmly attached* to the remaining alveolar bone and which remains vital beneath the usually discoloured exposed layer, is termed *dry socket* (**Fig 10** ). Dry socket is the most common (and a very painful) post-exodontia problem in humans where it is usually caused by absence of an adequate intra-alveolar blood clot to protect the exposed alveolar bone. Dry socket has only recently been recognised in horses (Horbal *et al.* 2018; Kennedy *et al.* 2020), but possibly all non-healing alveoli without obvious infection or sequestrae could be considered to be affected by this disorder. Such alveoli, that are often painful, need repeated monitoring and packing to cover the exposed alveolar bone. It may take many weeks for the superficial bone layer to be shed or resorbed and the underlying healthy bone to then become covered in granulation tissue to allow alveolar healing.

### **Continuation of unilateral nasal discharge**

The failure of dental sinusitis cases to resolve following exodontia may be related to one of the above described alveolar disorders, but is much more likely to be caused a residual sino-nasal problem (Dixon *et al.* 2019). Such cases should have the affected alveolus examined and, if it contains sequestrae and/or is infected, or if it has a communication with the sinus, these disorders should be treated. However, the more likely causes for non-response of dental sinusitis are the presence of inspissated exudate or bone sequestrae in the affected sinuses or intercurrent nasal disease including nasal conchal bulla infections (Dixon *et al.* 2019, 2021).

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## Figure Legends

**Fig 1.** The left image shows a maxillary cheek tooth being repelled under general anaesthesia. The right image shows typical damage to a repulsed tooth, with its apical area extensively fractured that predisposes to retention of dental fragments.

**Fig 2 .** Radiograph of an apically infected mandibular Triadan 08 in a young horse with a thin metallic probe inserted into a ventral draining tract. Note the extensive bone changes at the caudal and apical aspects of the alveolus (arrows). Exodontia of this tooth has a higher risk of post-extraction problems as this is a rostral mandibular cheek tooth, is apically infected and in a young horse.

**Fig 3.** These extracted Triadan 10 mandibular cheek teeth are from two mature horses that had bilateral Triadan 10 developmental displacements and long term periodontal disease. Exodontia of these teeth with long curved tapering roots resulted fracture of one caudal (distal) root as shown in the left image and one rostral (mesial) and one caudal (distal) root in the teeth as shown in the right image.

**Figure 4.** This radiograph of normal rostral mandibular cheek teeth in a young horse has the periodontal space rostral to the Triadan 07 indicated by a yellow arrow. The adjacent lamina dura (bundle bone or cribriform plate) (white arrow) overlies the larger expanse of spongy bone (SB).

**Fig 5.** The left image shows a non-healing, post-extraction alveolus with thin alveolar sequestrae (arrows) visible in its lumen. A small granuloma-type lesion is present on the top left of image. The right image shows some of the sequestrae that were removed from this alveolus.

**Fig 6 .** Left: This parasagittal CT image is of a horse with alveolar osteomyelitis and sequestration following exodontia of 408. Note the gross soft tissue swelling overlying the affected alveolus (white arrow), alveolar thickening and remodelling and a large sequestrum of its lateral wall (star). Right: this transverse CT image of this case in a slightly different plane, also shows the overlying soft tissue swelling (white arrow), gross alveolar wall remodelling and an intra-alveolar sequestrum (yellow arrow). The alveolus of (maxillary) Triadan 208 which underwent exodontia the previous year is fully healed.

**Figure 7 .** The left image shows the mandible in Fig 6 with post-exodontia osteomyelitis, sequestration, overlying soft tissue swelling and widespread alveolar bone changes. The right CT image of this same site was obtained 8 months later when the infection had resolved. It shows a shortened mandible with reformation of its walls and the 408 alveolar lumen filled with osteoid material.

**Fig 8 .** This transverse CT image taken following exodontia of 206 shows a large oro-nasal fistula filled with food (arrows). There also is almost total loss of the surrounding alveolus and supporting bone that will make repair of this fistula problematic. (Fig courtesy of Dr Eric Parente).

**Fig 9.** These intra-oral images show a large oro-maxillary (oro-sinus) fistula at the site of a repulsed 109 (arrows). The dental mirror in the right image shows the fistula to be filled with forage. This neglected fistula is expanding in a palatal direction and will be increasingly difficult to treat.

**Fig 10.** This oral endoscopic image shows a non-healing alveolus that contains no blood clot, has exposed, discoloured porous-appearing bone (yellow arrow) over much of its surface with some forage fibres visible (black arrow). Healthy granulation tissue is only present at the occlusal aspect of the alveolus. Such alveoli need assessment to determine if the exposed bone is loose (i.e., is an alveolar sequestrum) or whether it is affected by “dry socket” as was the case for this alveolus.











