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Equine cheek tooth extraction: Comparison of outcomes for five extraction methods

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Summary

Background: Post-operative complications are reported for all methods of equine cheek tooth extraction but not all methods carry the same risks. An outcome comparison for commonly used methods is needed so that clinicians can make informed treatment decisions.
Objectives: We conducted a side-by-side comparison of five cheek tooth extraction methods, comparing types and incidence of complications among oral extraction, tooth repulsion (three surgical approaches) and lateral buccotomy techniques.
Study design: Retrospective clinical study using hospital medical records.
Methods: Medical records of all horses undergoing cheek tooth extraction between 1997 and 2013 were reviewed. Logistic regression was used to determine the likelihood of various post-operative complications, comparing oral extraction, tooth repulsion by maxillary and mandibular trephination or maxillary sinus bone flap, and lateral buccotomy.
Results: The study included 137 horses and 162 cheek teeth extractions. Oral extraction was successful in 71% of patients in which it was attempted. Oral extraction (n = 55) had the lowest incidence of complications (20%) and repulsion by sinus bone flap (n = 20) the highest (80%). Complication rates for repulsion by maxillary (n = 19) and mandibular trephination (n = 28), and extraction by lateral buccotomy (n = 15) were 42, 54 and 53%, respectively. Cheek tooth repulsion by sinus bone flap significantly increased the odds of damage to adjacent teeth, post-operative sinusitis, damage to alveolar bone, delayed alveolar granulation and orosinus fistulation. Repulsion by maxillary trephination significantly increased the odds of superficial incisional surgical site infection; and extraction by lateral buccotomy significantly increased the odds of facial nerve neuropraxia. Post-operative pyrexia was more common in all repulsion methods.
Main limitations: Some clinically relevant differences may have been missed due to small group numbers in several categories.
Conclusions: Oral extraction was associated with fewer post-operative complications than any other methods. Standing oral extraction remains the preferred choice, and recent surgical advances promise to further improve its success rate.

Keywords: horse; tooth; molar; extraction; complication

Introduction

In horses, cheek tooth extraction (exodontia) is indicated for a variety of conditions, including cheek tooth fracture, displacement, maleruption/impaction or supernumerary tooth; periapical infection, with or without dental sinusitis; neoplasia; and severe periodontal disease. Because the equine premolars and molars have compound roots and, particularly in young adults, long reserve crowns, cheek tooth extraction in horses can be challenging and carries a significant risk for intra- and post-operative complications [1–17].

Complications include cheek tooth fragmentation and incomplete removal of all dental fragments; damage of adjacent cheek teeth; persistent dental sinusitis; delayed alveolar granulation, resulting in trapping and subsequent putrefaction of food in the open alveolus; damage to the alveolar bone, resulting in sequestration and/or osteomyelitis; incisional infection; fistulation (orosinus, oronasal, or orocutaneous); regional nerve damage (facial, infraorbital, or mandibular nerve); haemorrhage (e.g. laceration of the palatine or mandibular artery); and parotid duct injury [6,8,11–14,17].

Reported complication rates vary considerably among studies, from less than 4% to over 70%, but generally they are lowest for oral extraction in the standing horse and highest for repulsion of maxillary cheek teeth under general anaesthesia [1–3,6,8,15]. Extraction methods continue to evolve, with an emphasis on less traumatic approaches that minimise damage to the alveolar bone and adjacent CT. One such technique is the minimally invasive transbuccal technique [18,19] which is used to remove fractured cheek teeth that cannot be successfully extracted orally and has few of the disadvantages of the traditional lateral buccotomy technique [12,14,20].

In 2000, Dixon *et al.* published a landmark study of 349 horses with cheek tooth disease, reporting separately on outcomes for oral extraction and surgical repulsion in horses with disorders of cheek tooth wear, trauma, idiopathic fractures, tumours and apical infections [1,2]. To further expand a side-by-side comparison of the various methods of cheek tooth extraction in current use, we analysed three techniques (oral extraction, repulsion and lateral buccotomy) including the three most common approaches for tooth repulsion (maxillary trephination, mandibular trephination and by sinus bone flap) in our hospital patient population, in order for clinicians to make informed treatment decisions and advise clients accordingly. Thus, our hypothesis was that the incidence of post-operative complications is lower for oral extraction than for any of the other extraction methods, and that lateral buccotomy is associated with fewer post-operative complications than the surgical methods involving repulsion of the entire tooth.

Materials and methods

In this retrospective study, medical records were examined for all horses admitted with the chief complaint of dental disease and that underwent a dental procedure at the George D. Widener Hospital for Large Animals between 1997 and 2013. The study group comprised all horses that had at least one cheek tooth removed and for which the following data were available in the medical record.

Demographic and clinical data collected included age (divided into three age categories: <10, 10–20, >20 years), breed, gender and body weight. With specific reference to nasal and oral examination at admission, the following observations were recorded: nasal discharge (uni- or bilateral), cheek tooth affected, presence and type of cheek tooth fracture (lateral, midline/sagittal, etc), oral ulceration, gross gingivitis, other missing cheek tooth/teeth, the presence of dental displacement or dental drift or other abnormal dentition. The Triadan system of identification was used to

record which of the maxillary (106–111 and 206–211) and mandibular (306–311 and 406–411) cheek teeth were affected.

Extraction methods

Horses were divided into five groups according to cheek tooth extraction method: 1) oral extraction [3,6]; repulsion of maxillary cheek tooth into the oral cavity by 2) trephination [5] or 3) maxillary sinus bone flap [21,22]; 4) repulsion of mandibular cheek tooth into the oral cavity by trephination using a ventral mandibular approach [5]; and 5) lateral buccotomy [14,20] (maxillary or mandibular cheek tooth). Cases where oral extractions had to be completed by other methods were categorised as the definitive extraction method that allowed successful removal of the tooth. The number and location of cheek teeth removed were recorded for each procedure. The type of anaesthesia/analgesia was also recorded for each procedure, categorised as standing sedation, general anaesthesia or both (extraction attempted under sedation but completed under general anaesthesia). In addition, the use and type of alveolar packing following extraction was recorded, categorised as none, plain gauze, zinc oxide (Selan Plus)[a]–iodophor[b]–petrolatum (ZIP)–impregnated gauze[c], plaster of Paris (PoP) (Zoroc)[d], bone cement (polymethylmethacrylate, or PMMA) (Technovit Acrylic Powder J-61PA)[e] or alginate (HSI Alginate [HSI Spearmint®])[f]. Duration (days) and total cost of hospitalisation (US dollars) were also calculated for each horse.

Post-operative complications

Follow-up data were obtained from hospital records and from the horse's primary-care veterinarian. Post-operative complications recorded either during hospitalisation or at follow-up were categorised as none; injury to an adjacent tooth (fracture, periodontal disease, or abscessation, dental misalignment); damage to the alveolar bone (fracture, sequestration or osteomyelitis; 'nonhealing' alveolus due to dental fragmentation and incomplete removal of dental or other forms of debris); fistula formation (orosinus or orocutaneous); post-operative sinusitis (persistent and manifested after cheek tooth extraction); superficial incisional surgical site infection (SSI); neuropraxia (facial, infraorbital, or mandibular nerve); pyrexia (>38.7°C); and pneumonia. The recovery period was defined as the time between cheek tooth extraction and return to the horse's normal routine, categorised as <2, 2–4 weeks, 1–2, or >2 months.

Data analysis

A preliminary exploratory analysis was conducted using Fisher's exact test between categorical outcomes of interest and independent variables. The uncovered associations were studied further using logistic regression to establish the strength and significance of the associations of dichotomous outcomes (e.g. incisional infections) with categorical or continuous predictors (e.g. prior tooth extraction methods). The extraction methods were confounded by age category and tooth location and the analysis of the likelihood of specific complications was performed. The surgeon experience effect on complication rates was also investigated. However, since in our referral institution two surgeons are always involved as primary and secondary surgeon and because of a large variety of surgeons over many years (21 primary surgeons and 29 secondary surgeons), two categories were created: 1. Diplomates and 2. Residents (more and less experienced surgeons), and the incidence of complications comparing if the status of diplomat has any impact in each of the four combinations (diplomate/diplomate, resident/diplomate, diplomate/resident, resident/resident) was analysed.

All associations were assessed on their statistical significance and the OR ratio where values higher than 1 indicate increased likelihood of the outcome and less than one indicating decreased likelihood.

Two-sided tests of hypotheses and a $P < 0.05$ was used as a criterion for statistical significance. All statistical analysis was performed using Stata15 MP[g].

Results

A total of 137 horses met the study criteria; all survived to hospital discharge. Of the 137 horses, 69 were geldings, 55 females and 13 intact males with a body weight from 82 to 832 kg (mean, 497 ± 148 kg). Patient age ranged from 1 to 27 years (mean, 10.6 ± 6.4 years). These and other patient characteristics summarised in Figure 1 are representative of the general hospital population. As anticipated, older horses were more likely to undergo oral extraction. Both horses between 10 and 20 years (OR: 2.79, $P = 0.009$) and above 20 (OR: 12, $P < 0.001$) were likely to have oral extractions relative to young horses. Repulsion techniques (grouped together) were more likely in young horses with horses older than 10 years having lower likelihood of this procedure (OR: 0.46, $P = 0.036$ for horses 10–20 years; and OR: 0.1, $P = 0.003$ for horses> 20 years). There was no age predilection with regards to buccotomy.

Perioperative findings, including preoperative abnormalities and extraction method, are summarised in Table 1. Chronic sinusitis (2–3 months duration), was diagnosed more frequently in horses that underwent repulsion via sinus bone flap (55%) compared with horses belonging to the repulsion by maxillary trephination or to the oral extraction group (15.8 and 14.5%, respectively).

A total of 162 extractions were performed: 117 maxillary cheek teeth (72%) and 45 mandibular (28%).

Extraction methods

Oral extraction was the sole means of cheek tooth extraction in 55 horses. Of the 68 cheek teeth thus removed, 56 (82%) were maxillary cheek teeth and 12 mandibular. Oral extraction was initially attempted in another 22 horses but it had to be completed by repulsion technique by maxillary (six cases) and mandibular trephination (five cases), by sinus bone flap (four cases) or lateral buccotomy (seven cases). Thus, the overall success rate of oral extraction was 71%. Repulsion methods were used to extract 47 maxillary (21 via maxillary trephination and 26 via sinus bone flap) and 31 mandibular teeth (mandibular trephination). Lateral buccotomy was used to remove either maxillary or mandibular cheek teeth, with a prevalence of maxillary cheek teeth (14/16 teeth; 88%).

Most oral cheek tooth extractions were performed in the standing horse, using sedation and regional anaesthesia/analgesia, whereas all but one of

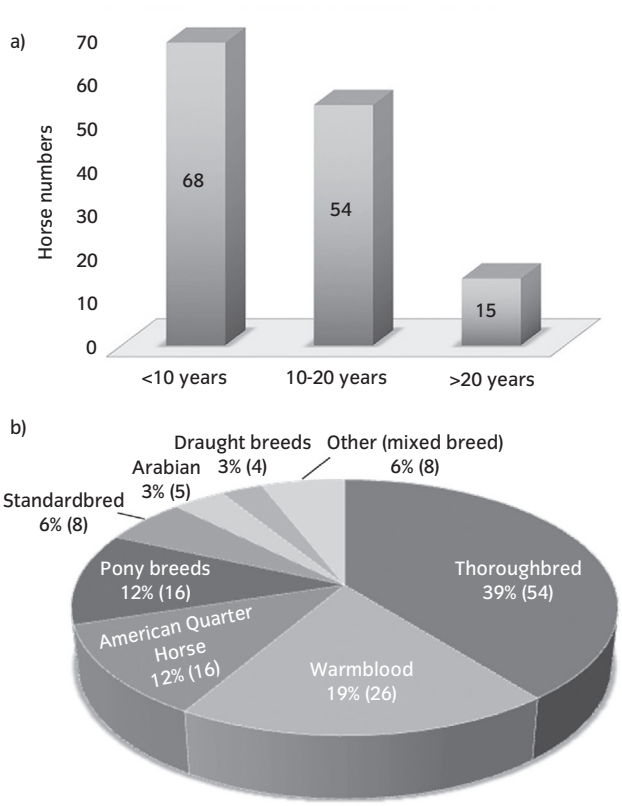

Fig 1: Age a) and breed b) distribution of the 137 horses included in the study.

TABLE 1: Perioperative findings in the 137 horses that underwent cheek tooth extraction

Variable	n (%)	Variable	n (%)
Nasal and oral exam[1]		Number of teeth extracted	
Nasal discharge	49 (35.8%)	1	117 (85.4%)
Abnormal dentition	15 (10.9%)	2	16 (11.7%)
Oral ulceration	7 (5.1%)	3	3 (2.2%)
Gingivitis	6 (4.4%)	4	1 (0.7%)
Missing cheek tooth	4 (2.9%)	Total	162 teeth
Dental displacement	2 (1.5%)	Most common tooth affected	
Dental drift	1 (1.4%)	209	31 (22.6%)
Fractured tooth[1]	55 (40.1%)	109	20 (14.6%)
1 tooth	48 (35.0%)	208	14 (10.2%)
2 teeth	7 (5.1%)	108	12 (8.8%)
Most common site	62 teeth (100%)	307	8 (5.8%)
209	14 (22.6%)	110	8 (5.8%)
109	12 (19.4%)	Extraction method	
309	5 (8.1%)	Oral	55 (40.1%)
Type of fracture	62 teeth (100%)	RPL method	
Lateral (slab)	3 (4.8%)	Maxillary trephination	19 (13.9%)
Midline or sagittal	23 (37.1%)	Sinus bone flap	20 (14.6%)
Miscellaneous pattern	28 (45.2%)	Mandibular trephination	28 (20.4%)
Unknown[2]	8 (12.9%)	Lateral buccotomy	15 (10.9%)

Except where noted, n (%) represents the number (percentage) of horses for that variable. RPL, repulsion.
[1]Findings recorded during physical examination at admission.
[2]Not described.

the other extraction methods were performed or completed under general anaesthesia (Fig 2). All 137 horses recovered uneventfully from sedation or general anaesthesia, with one complication associated with general anaesthesia (corneal ulcer).

Alveolar packing was used in 115 horses (84%); the alveolus was left exposed in the remaining 22 horses (16%), which underwent oral extraction. When packing was used, the most common material was PoP[c] (72 cases, 63%); ZIP[a, b] impregnated gauze was used in 19 cases (17%), PMMA[d] in 17 cases (15%), alginate[e] in four cases, and plain gauze in three cases. The number of days the packing remained in the alveolus ranged from < 1 to 205 days (average, 34 days).

Post-operative complications

Post-operative complications were reported with all extraction methods, but the types and incidence varied with extraction method (Table 2). In all nine major categories of complications recorded, oral extraction had the lowest rate of complications (20%) while repulsion by sinus bone flap had the highest (80%). Complication rates for the other techniques were 42 and 54% for repulsion by maxillary and mandibular trephination, respectively, and 53% for lateral buccotomy.

Damage to an adjacent tooth during extraction occurred in 5% of all cases (Table 2). Damage comprised fracture of an adjacent tooth (two cases), periodontal disease (two cases), tooth root fracture with subsequent abscessation (two cases) and dental misalignment (one case). When confounded for tooth location and age category, damage to an adjacent tooth was significantly associated with cases where repulsion methods were utilised (Table 3).

Alveolar bone damage occurred in 9% of all cases. In each case, it was not recognised at the time of extraction but identified on follow-up examination by conventional radiographic films (not digital or computerised) and digital radiography (Fig 3). Alveolar bone damage occurred with all extraction methods except repulsion by maxillary trephination but only repulsion by sinus bone flap significantly increased the likelihood of this complication (Table 3).

Orocutaneous or orosinus fistula formation occurred in 3 and 11% of all cases, respectively. Orocutaneous fistulation occurred only with repulsion by mandibular trephination, whereas orosinus fistulation occurred with all other extraction methods, including oral extraction. However, only repulsion by sinus bone flap significantly increased the likelihood of fistulation; it also significantly increased the odds of post-operative sinusitis (Table 3). Post-operative sinusitis occurred in 15% of cases and with all extraction methods except, of course, mandibular trephination. It was first diagnosed between one and 122 days after surgery (average, 31 days).

Delayed alveolar granulation occurred in 13% of cases, with all five extraction methods, due to the presence of alveolar bone sequestrum, persistent sepsis (presence of fistula) and undiagnosed dental fragments in the alveolus. In two cases the cause could not be determined. However, this complication was strongly associated with repulsion in general ($P < 0.001$) and with sinus bone flap specifically (Table 3). There was no significant association between its occurrence and the use or type of alveolar packing.

Superficial incisional SSI occurred in 15% of cases with all extraction methods that entail a skin incision but superficial incisional SSI likelihood was significantly increased only with maxillary trephination (Table 3).

Post-operative pyrexia was reported in 5% of cases and was significantly associated with all repulsion methods. These horses first became febrile between 4 and 42 h after surgery (average, 20 h), with rectal temperatures in the range of 38.8–40.0°C (average, 39.2°C). Pyrexia (OR: 0.1 P: 0.036) was less likely to occur when the primary and secondary surgeons performing the procedure were diplomates.

Transient facial nerve paralysis was reported in 4 horses (3%) and its incidence was significantly associated with lateral buccotomy. Only one horse developed post-operative pneumonia following a lateral buccotomy for an alveolar osteomyelitis with the same bacteria specie cultured in both the dental alveolus and the trans-tracheal wash.

A second surgical procedure was required in 20 horses (15%). The need for further surgical intervention occurred with similar frequency among all five extraction methods (10–15% of patients in each group) (Supplementary Item 1).

Treatment costs and recovery times

Average total treatment costs during hospitalisation were lowest for oral extraction and highest for maxillary sinus bone flap. Follow-up information was available for 102 horses. More than half (53%) returned to their previous exercise routine (light work) <2 weeks after surgery and 95% by 2 months after surgery. Further details are provided in Supplementary Item 1.

Discussion

As anticipated, the incidence of post-operative complications was lowest for oral extraction than for any of the surgical extraction methods included in our study. However, our hypothesis, that lateral buccotomy was associated with fewer complications than other methods involving repulsion of the diseased tooth, was rejected.

Before discussing our findings in more detail, the main limitations of our study must be acknowledged. First, the small and disparate number of subjects in the various treatment and complication groups may have obscured some clinically relevant associations that did not reach statistical significance in our study. Second, this was a retrospective study that spanned 16 years, during which surgical techniques and perioperative care continued to evolve. Third, this study was conducted in a veterinary teaching hospital so it included multiple surgeons of diverse experience and preferences. Lastly, logistic regression models are only as good as the set of variables selected and the data used. We based our choice of variables on clinical experience and evidenced based research regarding the types and rates of post-operative complications for the extraction methods under investigation and were limited by the need to rely on historical data from archived medical records.

Of the five extraction methods analysed in this study, repulsion of maxillary cheek teeth incorporating a maxillary sinus bone flap was associated with the highest overall incidence and variety of complications, it was performed under general anaesthesia, and it was the most

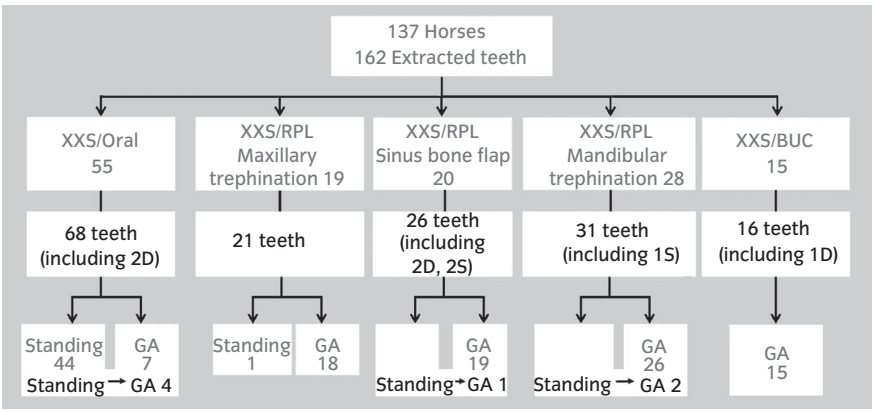

Fig 2: Methods of anaesthesia/analgesia used in the 137 horses that underwent cheek tooth extraction. XSS/Oral, extraction of a tooth per os; XSS/RPL, extraction of a tooth via repulsion; XSS/BUC, transbuccal extraction of a tooth after lateral buccotomy; D, deciduous; GA, general anaesthesia; S, supernumerary; Standing, sedation and perineural anaesthesia in standing horse; Standing → GA, procedure attempted in standing horse but completed under GA.

TABLE 2: Post-operative complications in the 137 horses that underwent cheek tooth (CT) extraction (XSS)

Complication	All methods (n = 137) n (%)	XXS/Oral (n = 55) n (%)	MX/TRP (n = 19) n (%)	XSS/RPL SIN/F (n = 20) n (%)	MAND/TRP (n = 28) n (%)	XXS/BUC (n = 15) n (%)
Damage to adjacent teeth	7 (5.1%)	–	1 (5.3%)	5 (25%)[a]	–	1 (6.7%)
Damage to alveolar bone	12 (8.8%)	2 (3.6%)	–	4 (20%)[a]	4 (14.3%)	2 (13.3%)
Orocutaneous fistula	4 (2.9%)	–	–	–	4 (14.3%)	–
Orosinus fistula	15 (10.9%)	4 (7.3%)	3 (15.8%)	5 (25%)[a]	–	3 (20%)
Delayed alveolar granulation	18 (13.1%)	1 (1.8%)	2 (10.5%)	5 (25%)[a]	7 (25%)	3 (20%)
Post-operative sinusitis (total)	20 (14.6%)	6 (10.9%)	3 (15.8%)	8 (40%)[a]	–	3 (20%)
Persistent sinusitis	11 (8%)	3 (5.45%)	3 (15.8%)	4 (20%)	–	1 (6.6%)
Sinusitis post-CT extraction	9 (6.6%)	3 (5.45%)	–	4 (20%)	–	2 (13.3%)
Superficial incisional SSI	20 (14.6%)	–	5 (26.3%) [a]	3 (15%)	10 (35.7%)	2 (13.3%)
Neuropraxia facial n.[1]	4 (2.9%)	–	1 (5.3%)	–	–	3 (20%)[a]
Pyrexia	7 (5.1%)	–	2 (10.5%)	1 (5%)	3 (10.7%)	1 (6.7%)
No complications[2]	79 (57.7%)	44 (80%)	11 (57.9%)	4 (20%)	13 (46.4%)	7 (46.7%)

Except for "All methods", n (%) in each column represents the number (percentage) of horses in that treatment group with that complication. XSS/Oral, extraction of a tooth per os; XSS/RPL, extraction of a tooth via repulsion; TPR, trephination. Surgical access to maxillary (MX/TRP) or mandibular (MAND/TRP) cheek tooth via a trephined hole; SIN/F, surgical access to the sinus via a skin and bone flap; XSS/BUC, transbuccal extraction of a tooth after lateral buccotomy.

Superscripted letters represent significant difference among cheek tooth (CT) extraction groups, [a]P≤0.001.

[1]Transient facial nerve paralysis was the only type of neuropraxia reported.

[2]The number of horses in each treatment group with no complications does not equal the column total for that group, as some horses had more than one complication.

expensive method. However, it must be noted that in the time interval the study was conducted, the sinus bone flap approach in conjunction with tooth repulsion was often elected due to the chronicity of the sinusitis and lack of response to other treatment regimens. The high prevalence of post-operative sinusitis with this repulsion approach was in part attributable to the high percent of persistent sinusitis (50%) and was part of the presenting complaint. After confounding all complications by the tooth location and the age of the horse, we confirmed that post-operative sinusitis was more likely to occur in the oldest horses. Chronic sinusitis revealed chronic granulation tissue and bacterial sequestration, based on culture of debrided tissue. In the early part of the study, this may have erroneously led surgeons to use a sinusotomy as the primary means of treating the sinusitis and removing the affected cheek tooth under general anaesthesia. The current method of choice would be to extract the tooth orally and treat the sinusitis standing using a minimally invasive technique [3].

Furthermore, maxillary cheek tooth extraction by sinus bone flap was the only extraction method that significantly increased the likelihood of alveolar bone injury compared with all extraction methods. One might have expected a greater likelihood of alveolar bone injury with "blind" repulsion by trephination than with sinus bone flap, which provides the surgeon an improved view of the tooth roots and surrounding structures. It is possible that chronic sinusitis affected the health of the alveolar bone in some of these patients. In support of this prospect, orosinus fistulation and post-operative sinusitis were significantly associated with maxillary cheek tooth extraction by sinus bone flap but not with maxillary trephination, which also involves surgical access into the rostral or caudal maxillary sinus for most maxillary cheek teeth.

Other explanations for the repulsion by sinus flap resulting in higher complications, could be related to technical errors. Intraoperative radiographic examination was used to guide cheek tooth repulsion but it is possible that in the earlier years of the study, fewer and less detailed intraoperative radiographs were acquired due to the long time-lag involved with conventional film processing. Unfortunately, we had no objective method to test for this difference. The dental punch was used in most cases, however, surgery reports in the medical records were not specific as to whether a dental punch or Steinmann pins was used.

In this patient population, oral extraction was associated with the lowest incidence of post-operative complications; it was also the most economical

TABLE 3: Results of logistic regression, comparing all cheek tooth extraction methods for each type of post-operative complication (outcome). Each association between the complication and the extraction method was confounded by the tooth location[1] and the age[2] of the horse (coefficients estimates not shown)

Extraction method	Odds ratio[3]	95% CI	P value
RPL – all methods			
Damage to adjacent teeth	11.5	4.0–33.2	<0.001
Superficial incisional SSI	5.0	2.6–9.5	<0.001
Postoperative pyrexia	3.6	1.2–10.6	0.019
Delayed alveolar granulation	2.9	1.6–5.4	<0.001
Post-operative sinusitis	2.4	1.4–4.2	0.001
RPL via maxillary trephination			
Superficial incisional SSI	3.5	1.7–7.3	0.001
RPL via sinus bone flap			
Damage to adjacent teeth	10.1	4.2–24.1	<0.001
Post-operative sinusitis	6.2	3.4–11.4	<0.001
Damage to alveolar bone	5.7	2.5–12.7	<0.001
Delayed alveolar granulation	4.9	2.4–9.8	<0.001
Orosinus fistula	3.4	1.8–6.7	<0.001
BUC			
Neuropraxia (facial n.)	24.9	7.8–79.5	<0.001

CI, confidence interval; RPL, repulsion; BUC, lateral buccotomy.
[1]Tooth location 0: tooth 106–108, 206–208, 208s 507–508, 608; Tooth location 1: tooth 109–111; 209–211, 209s; Tooth location 2: 306–311 310s; 406–411; supernumerary.
[2]Age category: Group 0: <10 years; Group 1: 10–20 years; Group 2: >20 years.
[3]Crude odd ratios.

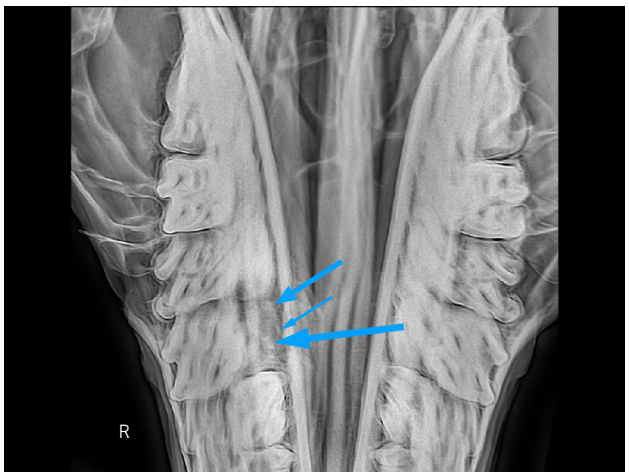

Fig 3: Radiographic image (straight DV view) showing alveolar bone damage (bony sequestra highlighted by the blue arrows) following 408 cheek teeth extraction by lateral buccotomy.

method of cheek tooth extraction. However, oral extraction was not always successful and in 60 cases was not even attempted due to the surgeon's preference. General anaesthesia was elected in several cases to complete oral extraction because of the inability to remove all dental fragments in the standing horse.

Most unsuccessful oral extractions primarily affected horses with a fractured tooth and meagre crown and secondarily young horses with plentiful reserve crown. In other studies, reasons for failure of oral extraction included fragmentation of the crown before appropriate periodontal loosening was achieved, with part of the tooth then inaccessible in the deeper recesses of the alveolus; insufficient crown, particularly in older horses; wedging of the affected tooth between adjacent cheek tooth; cemental reaction resulting in ankylosis of the tooth root; poor access to the tooth, particularly with the caudal molars; and poor patient compliance [1–3,6,8,11,15,17].

Other studies cite success rates of 80–90% for oral extraction [6,8,15], thus our results likely reflect our particular patient population (tertiary-care facility) and surgeon pool (veterinary teaching hospital). The analysis of surgeon experience as one of the important predictors of complications, revealed that pyrexia was less likely to occur when the primary and secondary surgeons performing the procedure were diplomates. However, it remains challenging to compare many clinicians, particularly if they oversee a surgery resident in training in a teaching hospital. Additional studies looking specifically at these aspects would help to clarify a likely predictor of surgical complications.

Nevertheless, our findings support the consensus that oral extraction is the method of choice whenever possible. It is notable that the most recent advances in equine cheek tooth extraction, such as the minimally invasive transbuccal approach with intradental screw extraction (MITSE) [18,19] and the partial coronectomy [23], are fundamentally oral extraction techniques in the standing horse. Standing oral extraction of fractured cheek tooth under endoscopic guidance [15] is another example of applying current technology to facilitate oral extraction of cheek teeth in the standing horse. Reported success rates for these procedures range from 81 to >99% with 3.6–14% complication rates [15,19,23].

In our study, lateral buccotomy had little advantage over repulsion of a maxillary or mandibular cheek tooth by trephination. Subjectively one might conclude that repulsion by trephination was a better technique for maxillary cheek tooth removal because while maxillary trephination significantly increased the odds of superficial incisional SSI, lateral buccotomy significantly increased the odds of neuropraxia of the facial nerve In addition, in 2 of the 15 horses in the lateral buccotomy group, the alveolar packing had to be replaced under general anaesthesia (Supplementary Item 1). In one case, the alveolar packing was difficult to remove because PMMA packing material was selected to close the opening between the oral cavity and sinuses. However, no information regarding the position or shape of the packing could be determined from the medical record. The horse's nature and the selection of the packing material was considered responsible in these cases, although it is possible that lateral buccotomy resulted in more post-operative pain than other extraction techniques.

Interestingly, incisional infection was significantly more likely with maxillary trephination but not with either of the other three extraction methods which entail a skin incision. This complication might have been prevented in many cases by improved post-operative wound management and, with maxillary trephination, repeated sinus lavage.

A more problematic complication to prevent and treat is delayed alveolar granulation, which encourages the trapping and subsequent putrefaction of food in the open alveolus. This complication occurred with every extraction method, although the risk was greatest with sinus bone flap, repulsion by mandibular trephination, and lateral buccotomy — three very different surgical approaches. The likely factors that affected the delay in alveolar granulation were alveolar bone sequestra, persistent sepsis (presence of fistula) and undiagnosed dental fragments in the alveolus.

In other studies involving oral extraction of cheek teeth, the authors emphasised the importance of several features: appropriate equipment; good patient restraint (sedation, analgesia and muscle relaxation); good visualisation of the affected cheek tooth; and patience, using gentle and steadily increasing force to completely remove the affected cheek tooth and minimise the risk of complications [1–3,6,15,24]. Although specific techniques of oral extraction were not investigated in this study, our findings support the published reports that oral extraction is the preferred method of cheek tooth extraction in horses. It is reassuring that recent advances in equine dentistry, such as MITSE and partial coronectomy, are expected to further improve the success and reduce the complication rates of oral extraction in the standing horse.

Authors' declaration of interests

No competing interests have been declared.

Ethical animal research

Research ethics committee oversight not required by this journal: retrospective analysis of clinical data.

Owner informed consent

Explicit owner informed consent for inclusion of animals in this study was not stated.

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Authorship

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Supporting Information

Additional Supporting Information may be found in the online version of this article at the publisher's website:

Supplementary Item 1: Subsequent surgical procedures, treatment costs and recovery times.