How to Identify Potential Complications Associated With Cheek-Tooth Extractions in the Horse

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Oral surgeries involving the extraction of cheek teeth have a very high complication rate. Complications have been reported at 32% and as high as 70%. Recognition before occurrence helps the veterinarian to reduce the incidence and be prepared for a complication(s). Common indications for extraction include dental fracture, end-stage periodontal disease, severe decay/cavity, and periapical abscess. Typical complications include iatrogenic dental fracture (arising from ankylosis, resorptive lesions, decay, or incomplete/abnormally developed teeth), alveolar bone sequestration, paranasal sinus infection, alveolar plug failure, fistula (oroantral, oronasal, etc.), root-tip fracture, pathology extending to additional teeth, palatine artery laceration, and iatrogenic mandibular fracture. Oral and radiographic findings that would alert the clinician to complications associated with cheek-tooth extraction include: radiographic evidence of root-tip ankylosis, recognition of devitalized bone with oral and radiographic examination, identification of alveolar plug failure and gross contamination of the sinus with feed material, detection of an oroantral fistula with an intraoral mirror, evaluation of retained/fractured root tips for a periodontal ligament, radiographic evaluation of collateral pathology extending interproximal to neighboring teeth, detection of incomplete gingival reattachment and the formation of a small oral fistula, recognition of a palatal deviation of a cheek tooth that may predispose to an oronasal/oroantral fistula and/or a palatine artery laceration, and identification of immature and/or endodontically challenged teeth that may predispose to fracture during an extraction procedure. Author’s address: Laurel Highland Farm and Equine Service LLC, 2586 Northway Road Ext., Williamsport, Pennsylvania 17701, e-mail: etearley@earthlink.net. © 2010 AAEP.
directly over the cheek tooth) to assist in surgical extraction.5 With perineural anesthesia6,7 and appropriate sedative combinations,8–10 most extraction procedures can be performed with the horse standing.

Radiographic evaluation has been described by using extraoral and intraoral techniques. A hands-free and opened-mouthed technique may be used in a standing sedated horse.11–14

2. Terminology

When examining a fractured cheek tooth, the extent of the fracture should be evaluated to determine if it involves only the clinical crown or extends to the reserve crown. Occasionally, the root tip will be involved. Pulp-horn exposure should be determined and documented. The Veterinary Dental Nomenclature [American Veterinary Dental College (AVDC)]15,16 currently defines a fracture according to pulp, crown, and root exposure. The current fracture classifications and abbreviations are shown in Table 1.

3. Materials and Methods

Equipment

A base level of necessary examination equipment is similar as for other subdisciplines of dentistry, which includes an assortment of dental speculums (some may be better for radiography and others for procedures), a bright head lamp, large and small dental explorers, a periodontal probe, right- and left-angled diastema forceps, a dental mirror, and a digital camera. Additional equipment would include an X-ray machine, an assortment of extraoral and intraoral cassettes, an endoscope (a rigid arthroscope may also work), and orthopedic equipment for sinusotomy.

When selecting extraoral cassettes, the 8- × 10-in and 10- × 12-in cassettes are necessary, with larger sizes (14- × 17-in or 12- × 17-in) being an advantage for cases with sinus involvement. The recommended sizes for intraoral cassettes include the 4- × 8-in (maxillary cheek teeth and incisors) and 3- × 8-in (mandibular cheek teeth) cassettes. Additional sizes that may be of benefit include 4- × 4-in and 2.5- × 7-in intraoral cassettes.

Physical and Oral Examination

The examination process should include a whole-body approach. Dental extractions may require several hours of standing sedation and occasionally, general anesthesia. The cardiovascular and respiratory systems should be monitored. In older and/or debilitated patients, blood work may be indicated as a screening for liver and kidney functions, metabolic disorders, infection, anemia, etc.

A systematic intraoral and extraoral examination is required for appropriate assessment and treatment planning. Periodontal and endodontic diseases are staged by careful oral and radiographic examination. Malocclusions that predispose to the development of periodontal disease need to be identified. Profound sedation is required for this type of examination. The author prefers detomidine2 (0.01 mg/kg, IV) in combination with xylazine2 (0.11 mg/kg, IV).

Extraoral examination should include examination of the head/maxilla for swelling, fistulas, nasal discharge, malodorous breath, and percussion of the sinuses. As a general rule, the rostral maxillary sinus lies above the fourth premolars and first molars (08s and 09s), and the caudal maxillary sinus is associated with the second and third molars (10s and 11s). Check for any facial swelling above or lateral to the 06s or 07s (PM2 and PM3). These teeth are not involved with sinus disease. Both mandibles should be palpated along the medial and lateral ventral borders to determine if any irregular or abnormal thickness is present. Evaluate for masseter muscle asymmetry, muscle atrophy, heat, or swelling. Maxillary, incisive bone, and mandibular fractures should be ruled out before placement of a speculum. If there is any question, closed-mouth radiographs should be taken.17

Intraoral examination is performed using an intraoral mirror6 with a dental light7 (or an intraoral camera system18) in conjunction with a dental explorer8 and periodontal probe.7 A dental explorer is used to evaluate the teeth, focusing on defects, chips, pulp exposure, etc. The tactile sensitivity of a dental explorer increases as the size of the explorer head decreases (Fig. 1). A periodontal probe is used to evaluate the gingival attachment to the teeth. The head of the periodontal probe should be thin and flexible so that it can easily slide into small periodontal defects/pockets, and the incremental depth indicators should be easily visualized (Fig. 2). In addition, an intraoral examination should also include evaluation of the buccal walls of the cheeks, hard and soft palate, mucosa, and tongue.

### Table 1. AVDC Veterinary Dental Nomenclature and Dental Fracture Classification

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Classification and Description</th>
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<tr>
<td>UCF</td>
<td>Uncomplicated crown fracture—a fracture involving the enamel and dentin of the clinical crown without pulp exposure.</td>
</tr>
<tr>
<td>CCF</td>
<td>Complicated crown fracture—a fracture involving the enamel, dentin, and pulp of the clinical crown.</td>
</tr>
<tr>
<td>UCRF</td>
<td>Uncomplicated crown/root fracture—a fracture involving the enamel, dentin, clinical crown, and root without pulp exposure.</td>
</tr>
<tr>
<td>CCRF</td>
<td>Complicated crown/root fracture—a fracture involving the enamel, dentin, clinical crown, root, and pulp.</td>
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Radiographic Examination

The radiographic examination should also begin with the horse sedated. Detomidine\textsuperscript{a} and xylazine\textsuperscript{b} work well for extraoral views. In the author’s experience, the addition of butorphanol\textsuperscript{h} (0.01 mg/kg) and romifidine\textsuperscript{h} (0.04 mg/kg) is often necessary for intraoral radiography.\textsuperscript{8–10} All views can be taken with the horse standing and the head down and low to the ground. This stance is comfortable for the horse and the person taking the radiographs. For the extraoral views, the mouth is held open with a dental speculum\textsuperscript{i} that has minimal metal along the side of the horse’s face.\textsuperscript{11–14,19,20} The open-mouth view allows for the offset of the arcades when obtaining the extraoral views and the placement of film within the oral cavity for the intraoral views. The maxillary arcades are imaged by placing the film/screen within the oral cavity and using a bisecting technique. Intraoral views of the mandibular arcades are obtained by using a parallel or ventral oblique technique.\textsuperscript{17} The intraoral dorsal ventral and the intraoral ventral dorsal view can be taken with an aluminum speculum.\textsuperscript{jk19}

Radiographic examination is very useful when evaluating the periodontic and endodontic status of cheek teeth. The periodontal ligament is a soft-tissue structure that is the attachment, suspension, and support structure that holds the tooth within the alveolar socket. A healthy periodontal ligament appears as a regular smooth, thin black line around the entire reserve crown and root tip(s) (Fig. 3). Multiple radiographic views may be needed to evaluate the periodontal ligament. Common radiographic abnormalities of the periodontal ligament

![Fig. 1. Dental explorers.](image1)

![Fig. 2. Periodontal probes.](image2)

![Fig. 3. Periodontal ligament (green arrows). Pulp horns (pink arrows).](image3)

![Fig. 4. Periapical (green arrows). Common pulp chamber (upper four orange arrows). Root canal (lower four orange arrows). Pulp horn (pink arrows).](image4)
include an irregular/thickened outline (periodontitis) or absence of an outline (ankylosis/loss of periodontal ligament). The endodontic status is evaluated by examining the pulp horns, common pulp chamber, root canal, root tips, and periapical aspect of the tooth. The pulp horns are visualized with radiographic examination; however, they are difficult to individually identify because of the three-dimensional overlap (Figs. 3 and 4). The outlines of normal pulp horns are uniform, smooth, and regular in appearance. An inflamed pulp horn (pulpitis) can appear one of two ways radiographically. The first way is a necrotic pulp horn that is widened and irregular because of the decrease in dentin formation or internal resorption. The second type of radiographic appearance is a reactive pulp horn where the pulp horn becomes dense, thin, and irregular. Normal root tip(s) and periapical area have a regular continuous periodontal ligament without evidence of cemental reaction or blunting of the root tips (Fig. 4). The common pulp chamber and root canal is shown in Figure 4. Contralateral radiographic evaluation may be helpful when trying to distinguish if a finding represents dental pathology or if it is normal variant for the patient. In addition, follow-up radiographic evaluations are useful
when staging the progression/recession of dental pathology.

4. Results and Discussion

The following cases are presented as examples of typical complications that can occur after the extraction of a cheek tooth. Each case will have a brief description of the oral and radiographic examination. After each case will be a short discussion detailing the importance of the examination findings in association with identifying the complication. The goal is to be able to recognize a potential complication before it occurs. As a result of early recognition, the potential complication can be eliminated or minimized.

Iatrogenic Dental Fracture Caused by Ankylosis/Resorptive Lesions

A 21-yr-old horse presents with a fractured 408. The fracture involves the lingual aspect of the clinical crown (Fig. 5). Note that pulp horns #1, #2, #3, and #4 have been involved with the clinical crown fracture. In addition, pulp horn #5 has been exposed (Fig. 5, red arrows). The fracture was classified as a complicated crown fracture (CCF; Table 1). The intraoral radiograph of the 408 fracture reveals that the periodontal ligament is mostly absent in the distal root tip, with tooth resorption evident (Fig. 6, green arrows).

An oral extraction was attempted. The remaining clinical crown fractured into multiple fragments (Fig. 7). The intraoral examination reveals the remaining reserve crown still in place (Fig. 8). A buccotomy was performed to surgically extract/excise the reserve crown and root tips (Fig. 9).

Discussion

The fractured 408 (Figs. 5 and 6) should not be viewed as a simple extraction procedure. When there is evidence of tooth resorption and ankylosis of a tooth, this will make for a very difficult extraction procedure. An attempt to extract this type of tooth orally will typically result in fracturing the remaining clinical crown. A repulsion surgery would most likely be very difficult and could potentially cause extensive damage to the surrounding mandibular bone. The anatomical structure of a mandible consists of light alveolar and cancelous bone enveloped with a cortical plate on the medial and lateral aspect; most of the strength of the mandible is actually attributed to the large cheek tooth embedded within the bone. If excessive force is needed to extract a mandibular cheek tooth, severe damage and/or fracture of the surrounding bone is a possible complication (Fig. 10). When a case is presented with this type of oral and radiographic finding, the best option for extraction would be a buccotomy and surgical excision so that there is minimal trauma to the mandible.

Alveolar Bone Sequestration

Alveolar bone sequestration is a common complication after the extraction of a cheek tooth. Through trauma to the surrounding bone during an extraction procedure and/or local infection, a thin layer of devitalized bone (in association with the cribiform plate) develops within the alveolus. The devitalization of alveolar bone and formation of a sequestrum may occur, even in simple extraction cases. This creates a local infection/inflammatory response that will prevent gingival healing within the alveolus. The formation of a sequestrum typically occurs within 3–6 wk after an extraction procedure. Initially, the bone may start to look dark-colored, as shown in Figure 11, with a 2-day post-extraction intraoral examination. The 2-day post-extraction extraoral radiograph shows a very faint outline of a developing sequestrum (Fig. 12, green arrows). At 3 wk post-extraction, a shell of devitalized bone is evident with the intra-oral examination (Fig. 13, orange arrows) and the extraoral radiograph (Fig. 14, green arrows). In addition, a sequestrum is developing along the mesial and apical aspect of 406 (Fig. 14, red arrows). An intraoral ventral dorsal shows a large sequestrum that involves the 407 alveolus and the 406 (Fig. 15, green arrows).

Discussion

Large angled root-tip elevators were used to remove the sequestra and 406 in two stages. The first sequestra and tooth removed are shown in Figure 16. Figure 17 reveals the remaining sequestrum removed 2 wk later. After the additional tooth (406) and sequestra were removed, rapid alveolar bone remodeling
(Fig. 18) and gingival healing occurred (Figs. 19 and 20).

Extractions With Paranasal Sinus Involvement and Alveolar Plug Failure

Extractions involving the maxillary cheek teeth can have direct sinus pathology. The apical aspect of the caudal four maxillary cheek teeth (PM 4–08, M 1–09, M 2–10, and M 3–11) is separated from the overlying sinus by a thin layer of cortical bone. Pathology involving these root tips may erode through the cortical bone and extend into the sinus. A 9-yr-old Standardbred gelding presented with a history of a chronic left nasal discharge. Oral examination revealed a sagitally fractured complicated crown root fracture (CCRF) 209 involving the infundibuli and pulp horns (Fig. 21). Feed material was packed deep into the fractured tooth. The extraoral radiograph shows severe pathology with the left rostral maxillary sinus, which appears to be a direct extension from the CCRF 209 (Fig. 22, red arrows). The 209 was extracted as a standing procedure with a combination of a buccal oral approach and a standing repulsion. The sinus was aggressively lavaged daily for 3 days after the extraction. At 3 wk post-extraction, the left nasal discharge returned. The horse was rehospitalized for another 5 days for daily sinus lavage.

Discussion

When managing a dental case with sinus pathology, it is important to treat the existing sinus disease. Extraction of the tooth is only a partial treatment. Management of a sinus infection typically requires regular aggressive daily lavage for a minimum of 3–5 days. If the cause of the sinus infection is unclear or the sinus infection is resistant to treatment, a biopsy and culture are indicated.

Multiple materials may be used as an alveolar plug to form a barrier between the oral cavity and sinus. Examples of different materials include gauze, polymethylmethacrylate (PMMA), vinyl polysiloxane dental-impression material (VPS), CaCO3/
CaSO₄ (plaster of Paris), and dental wax. Frequent monitoring of the alveolar plug, flushing of the alveolus/sinus, and replacement of the plug are indicated. An alveolar plug may appear functional on initial examination (Fig. 23); however, most barriers do not completely seal. Figure 24 shows a thick layer of food material packed into the alveolus after removal of the VPS plug noted in Figure 23. After flushing the food material, an oroantral fistula was evident at the mesial palatal aspect of the 209 alveolus (Fig. 25, orange arrow). This was the cause of the continued left nasal discharge and reoccurring sinusitis. With management of the alveolar plug and sinus lavage, the sinusitis resolved, and the oroantral fistula healed.

Retained Root Tip(s)/Fractured Root Tip(s)
A retained root tip is a common complication that may occur after an extraction procedure. The case example shown is a CCRF of 308. The fracture is a sagittal fracture of the clinical crown that involves pulp horns #4 and #5 (Fig. 26). The extraoral radiograph reveals resorption of the distal root (Fig. 27, green arrows point to distal root tip). A remnant of the mesial root tip has fractured (Fig. 27, pink arrow points to tooth fracture-root fracture [T/FX/RF]), whereas the remainder of the mesial root is partially resorbed (Fig. 27, green arrows point to resorption and orange arrows point to residual periodontal ligament).
The 3-wk post-extraction intraoral examination reveals that a portion on the mesial root tip is exposed orally, and the distal root tip is covered with gingival overgrowth (Fig. 28). The post-extraction extraoral radiograph depicts the mesial root tip with a residual periodontal ligament (Fig. 29, orange arrows). In the same radiograph, the distal root tip appears to be mostly resorbed (Fig. 29, green arrows).

Discussion
When evaluating retained root tips after an extraction procedure, attention should be focused on the presence and quality of the periodontal ligament. If a healthy periodontal ligament is present, the final treatment goal should be removal of the root tip. It has been shown that the fibroblast cells within the periodontal ligament are responsible for normal eruptive forces. The forces are so inherent that the fibroblasts are able to elevate root pieces in culture plates.\(^\text{21}\) In clinical cases, this could be used to an advantage when treating/managing retained root tips. With follow-up examinations, the root tip may erupt to aid in final extraction of the root tip.

If the periodontal ligament becomes compromised in an infectious/inflammatory process, it may gradually transition into a granulomatous type of tissue, and the fibroblasts will no longer function with eruptive forces. At this stage, it is difficult to distinguish a difference radiographically between a healthy and compromised periodontal ligament. In small-animal dentistry, with certain resorptive lesions in cats, it has been advocated to perform a crown amputation and create a mucogingival flap to cover the remaining root tip.\(^\text{22,23}\) A similar technique/case report has been discussed in the horse involving resorptive lesions.\(^\text{24}\) As a general dental principle, if a periodontal space can be noted radiographically, attempts should be made to extract the remaining root tip. If the resorptive process has progressed and radiographic evidence of a periodontal ligament and/or a periodontal space is lacking, extraction of the remaining root tip(s) is probably unwarranted. If there is any question of a periodontal ligament, follow-up radiographs are indicated. Currently, this case is being monitored radiographically to determine if anything more should be done with the mesial root tip.

Pathology Extending to Additional Teeth
Determining the origin of dental pathology, which may involve multiple teeth, can be a challenge. Collateral pathology may extend interproximal to neighboring cheek teeth. As an example, the intraoral radiograph in Figure 30 shows blunting of the root tips with both 107 and 108. Small pieces of cementum are noted along the distal buccal root tip of 107 and the mesial buccal root tip of 108 (Fig. 30, red arrows). Generalized cemental reaction is evident at the proximal aspects of 107/108 and 108/109 (Fig. 30, orange arrows).
The focus of the dental pathology appears to be centered over 108; however, there is concern of long-term health with 107 and to a lesser extent, 109. It was elected to extract 108 and monitor 107 and 109. The immediate postoperative intraoral radiograph shows the proximal pathology of the two neighboring teeth (Fig. 31, orange arrows). The 2-day post-extraction intraoral examination reveals normal bone along the distal aspect of the empty 108 alveolus (Fig. 32, green arrows).

Discussion

When multiple teeth are involved with dental pathology, regular long-term follow-up is mandatory.

The case example showed (Figs. 30 and 31) involved 107 (PM 3), 108 (PM 4), and 109 (M 1). With the dental pathology centered on 108, it was decided to extract only 108 and monitor 107 and 109. At 1 yr post-extraction, the intraoral examination reveals a small fistula along the distal aspect of 107 (Fig. 33). The intraoral radiographic evaluation shows that the cemental reaction along the distal/apical aspect of 107 is still present with slight consolidation (Fig. 34, orange arrows). The mesial/apical aspect of 109 appears to have healed, with evidence of a normal healthy periodontal ligament (Fig. 34, pink arrows).

When multiple teeth are involved, it is important to have a complete evaluation during the initial examination. This is very beneficial when formulating and discussing a treatment plan with the owner. As a general dental principle, it is best to be conservative, attempt to leave teeth, if possible, and
monitor the pathology. Conservative treatments (such as local periodontal treatment) should be considered. If the pathology continues to progress and/or extend to other teeth, extraction is indicated. In this case, local periodontal treatment was instituted with a piezoelectric ultrasonic scaler and placement of an antibiotic. The 3-mo follow-up exam (1 yr and 3 mo post-extraction) revealed complete gingival reattachment in place of the fistula with subtle radiographic improvement. Oral and radiographic monitoring of 107 will continue.

**Palatine Artery Laceration**

The greater palatine artery courses subgingival along the medial aspect of the maxillary cheek teeth at the edge of the hard palate along the palatine groove/process. It is a direct extension of the maxillary artery that passes through the palatine canal and extends rostral to join its counterpart (right and left palatine artery) caudal to the incisors, where it enters the interincisive canal to form the incisive artery. Displacements of fragments from fractured upper cheek teeth may cause erosions and/or defects of the hard palate. This may be problematic when considering an extraction. An example is illustrated in Figure 35. In this case, there is a CCRF of 109 with palatal displacement of tooth fragments and gingival recession. A large fragment is displaced medial/palatal, creating a severe erosion defect of the hard palate (Fig. 35, green arrow). An intraoral radiograph reveals multiple dental fragments associated with the fracture (Fig. 36). The erosion defect has compro-

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*Fig. 21. Sagittal fracture 209—complicated crown root fracture (CCRF).*

*Fig. 22. Sagittal fracture 209 (CCRF). Pathology involved with the left rostral maxillary sinus (red arrows).*

*Fig. 23. Vinyl polysiloxane (VPS) alveolar plug.*

*Fig. 24. VPS removed from horse shown in Fig. 31. Evidence of plug leakage with food material packed underneath.*
mised the normal anatomy of the palatine groove and displaced the palatine artery in a medial direction.

Discussion

The palatine artery courses subgingival along the medial aspect of the maxillary arcades. Lacerations and tearing may occur when extractions involve the lateral edge of the hard palate and the palatine process/groove. The palatine groove does not completely enclose/protect the palatine artery. The artery is in close opposition to the alveolar bone of the maxillary cheek teeth. If extensive pathology is present along the medial/palatal alveolar wall, there is a risk of lacerating or tearing the artery when attempting an extraction. A severe fracture of 109 (CCRF) is used as a case example in Figures 35 and 36. When the fragments were removed, the right palatine artery was torn, and acute hemorrhaging ensued. A small piece of bone from the hard palate (with part of the palatine artery) was attached to the medially displaced fragment (Fig. 37). Because of the anatomy and limited exposure, treatment is typically limited to direct pressure for an extended period (~20–30 min) to control the bleeding.

Fig. 25. Food material removed from horse in Figs. 31 and 32. Fistula evident at the mesial palatal aspect (orange arrow).

Fig. 26. Sagittal fracture 308. PHs 4 and 5 involved. CCRF based on extraoral (EO) radiograph shown in Fig. 20. PHs 1, 2, and 3 appear normal (pink arrows).

Fig. 27. Sagittal fracture 308; at 3 wk post-extraction, the mesial retained root tip (RRT) is exposed (pink arrow). Distal RRT has gingival overgrowth (green arrow).

Fig. 28. Sagittal fracture 308 (CCRF). Green arrows show distal root-tip resorption. Mesial root tip shown with periodontal ligament/space (orange arrows), loss of periodontal space/resorption (two green arrows), and fractured root tip/cementum (T/FX/RF; pink arrows).
Iatrogenic Dental Fracture of a Mandibular Cheek Tooth With Abnormal and Incomplete Dentinal Maturation

When contemplating the extraction of a cheek tooth, the endodontic status and dental age of the tooth (age since eruption) should be considered. A severe endodontic infection will cause an irreversible or necrotic pulp. When an irreversible or necrotic pulp infection is present, the production of normal dentin ceases. As a result, the maturation of the endodontic anatomy/structure is more of a sclerotic/calcification process, which will make the tooth weak and brittle compared with a normal healthy developing cheek tooth. An example of an iatrogenic complicated crown fracture (Fig. 38) shows a fracture of the reserve crown approximately 46 mm below the occlusal surface. An extra-oral radiograph (Fig. 39) depicts the remaining reserve crown and root tips. The dental age of the 308 is 3 yr (3 yr post-eruption in a 7-yr-old horse). The pulpitis (periapical abscess, mandibular drainage) was present since the tooth was 1-yr-old (1 yr post-eruption in a 5-yr-old horse).

Discussion

The endodontic status and dental age should be considered when evaluating a tooth for an extraction procedure. Iatrogenic tooth fracture may be more likely to occur when attempting to extract a young undeveloped tooth or an older tooth that has been endodontically challenged at a young age. The strength of a cheek tooth is attributed to the layering structure of the dentin, enamel, and cementum. A young immature tooth has a large pulp supply (vascular, neurologic, and cellular) that gives rise to...
the developing dentin. The dentin plays a major role, with the internal elasticity of a cheek tooth giving the overlying enamel flexibility.27 The hard enamel layered between the dentin and cementum gives rigidity to the tooth. The production of cementum around the reserve crown contributes to the external strength and support.28 Without the support of cementum and flexibility of dentin, the enamel (remaining tooth) is very brittle.

The 3-yr-old mandibular cheek tooth that was endodontically challenged for 2 yr (Figs. 38 and 39) is evaluated with computed tomography (CT) in Figure 40 and compared with a normal 4-yr-old mandibular cheek tooth (Fig. 41). With the endodontically challenged tooth, the cross-sections at 15, 25, and 46 mm apical to the occlusal surface show the abnormal dentin compared with the healthy dentin in a normal cheek tooth at the same cross-sectional levels. The dentin of the abnormal tooth appears denser and/or calcified compared with the dentin of the normal tooth. Pulp horn diameter appears similar between these two teeth. These changes with the internal structure could possibly make the tooth more prone to an iatrogenic fracture during an extraction procedure (Fig. 40, green arrows).

The difference in structural development between a normal 1-yr-old cheek tooth and a normal 4-yr-old cheek tooth is shown with cross-sectional CT images. Cross-sections at 6, 12, 16, and 20 mm coronal to the apex are displayed in Figure 42. The CT images on the left (4-yr-old cheek tooth) reveal a thick layer of dentin with isolation of the root tips and endodontic system(s). In comparison, the images on the right (1-yr-old cheek tooth) have a very thin layer of dentin, with a common pulp chamber evident at 16 mm coronal to the apex. An undeveloped young tooth may be more prone to an iatrogenic fracture during an extraction process.

5. Summary
Complications involving cheek-teeth extractions are very prevalent. Over one-half of all cheek-teeth extraction cases have a potential for complication. The extraction process should never be viewed as a simple one-stop procedure. To avoid and minimize complications, a systematic approach involving intraoral and radiographic examinations should be instituted. Additional modalities for evaluation, such as CT, may be indicated before attempting an extraction procedure. Potential complications include (but are not limited to)
iatrogenic dental fracture (arising from ankylosis, resorptive lesions, decay, or incomplete/abnormally developed teeth), alveolar bone sequestration, paranasal sinus infection, alveolar plug failure, oral antral fistula, root-tip fracture, pathology extending to additional teeth, palatine artery laceration, and iatrogenic mandibular fracture.

Acknowledgments

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Fig. 38. Iatrogenic fracture of the reserve crown (T/FX/CCF).

Fig. 39. 308 (PM4) and iatrogenic fracture (CCF). Remaining reserve crown and roots. Wire probe placed through the draining tract (green arrow).

Fig. 40. Endodontically challenged 3-yr-old cheek tooth (3 yr post-eruption). The pulpitis started at 1 yr post-eruption. CT sections at 15, 25, and 46 mm apical to the occlusal surface. Note the absence of normal dentin. A dense sclerotic/calciﬁed layer is present in place of a normal dentinal layer (green arrows).

Fig. 41. Normal 4-yr-old cheek tooth (4 yr post-eruption). CT at 15, 25, and 46 mm apical to the occlusal surface. Note the thick/healthy dentin layer (green arrow).
Fig. 42. (Left) Normal 4-yr-old (post-eruption) mandibular cheek tooth. (Right) Normal 1-yr-old (post-eruption) mandibular cheek tooth. CT sections at 6, 12, 16, and 20 mm coronal to the apex. Note the communication to all pulp horns (common pulp chamber) in the 1-yr-old cheek tooth at 16 mm coronal to the apex.

Fig. 36. 109 CCRF on IO radiograph.
References and Footnotes


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