Infundibular Caries

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In the horse the incisors and maxillary cheek teeth have enamel invaginations called infundibula that penetrate the occlusal surface. The infundibula provide the occlusal surface with additional enamel. These infundibula are filled or partially filled with cementum and normally have a pin-like hole in the center of the occlusal surface of the cementum that generally travels the length of the infundibulum. This defect is the site of the former blood vessels present when cementum was laid down during development. During development, the infundibulum receives the majority of its blood supply from the occlusal aspect of the tooth, but some studies suggest that there may also be a blood supply from the apical aspect.[a] The incisors have a single infundibulum termed a "cup" and the maxillary teeth each have two infundibula. The mandibular teeth have none. Incisor infundibular caries is rare. Infundibular caries of the maxillary cheek teeth exist to some degree in the vast majority of aged horses examined.

Infundibular decay or caries is the most common type of decay in horses' teeth and cemental hypoplasia, i.e. incomplete filling of the maxillary cheek teeth infundibula with cementum is the most common reason for infundibular decay. In a normal tooth, the infundibulum is filled with cementum. Cemental hypoplasia is believed to be a problem that occurs during tooth development. Early disruption of the blood supply to the infundibulum could result in a lack of cementum formation. It is not always possible to detect cemental hypoplasia from the occlusal surface. One hypothesis is that excessive deposition of infundibular cementum near the occlusal surface constricts the blood supply to the cementocytes deeper within the infundibulum. This could explain the lack of cementum deeper in the infundibulum while the surface has a layer of cementum. This pattern of cementum deposition can result in a normal appearing infundibulum in a young horse and years later the infundibulum will appear to be hypoplastic and filled with debris. Premature removal or loss of deciduous teeth (caps) also disrupts the blood supply to the occlusal surface of the permanent tooth. Once the occlusal surface blood supply is disrupted and the occlusal surface exposed, cementum is no longer produced in the infundibulum.

Defects of cementum within the infundibulum allow food material and bacteria to accumulate in the center of the tooth. Fermentation and acid production leads to decalcification of the surrounding cementum, and later in some cases will also involve enamel, and later dentine. Decay causing coalescing of the two infundibula weakens the center of the tooth and can lead to a saggital fracture and a split tooth (Figs. 1 and 2). Decay of the cementum progressing through the enamel and dentine into the pulp chamber of the tooth will lead to infection and may often lead to an apical abscess that

Figure 1. Split molar 109 due to infundibular caries.

Figure 2. Split molar extracted due to infundibular caries.

can cause sinusitis and/or a draining fistulous tract. A modified Honma classification for tooth decay can be used to grade the severity of infundibular decay.[1]

0. zero-degree caries: no evidence of caries on a macroscopic level, but may include hypoplastic tissue (i.e. central infundibular cemental hypoplasia).
1. first-degree caries: caries only affecting cementum - this may vary considerably from small darkly pitting superficial spots, to extensive destruction and loss of cementum. On this basis, it may be divided into 1 and 2, respectively.
2. second-degree caries: extends beyond cementum to affect adjacent enamel.
3. third-degree caries: extends beyond cementum to affect enamel and dentine.
4. fourth-degree caries: where caries has progressed to affect the integrity of the entire tooth, i.e. development of an apical abscess or tooth fracture.
5. fifth-degree caries: caries resulting in tooth loss.

One should become familiar with the differences between the location and occlusal appearance of the pulp chambers and infundibuli of the maxillary cheek teeth (Fig. 3).[2] The maxillary cheek teeth have between five and eight pulp chambers and are recognized by the darkly stained secondary dentine. They also have two infundibula with light cream-colored cementum. The mandibular cheek teeth only contain five to seven pulp chambers and no infundibula. A thin probe should not be able to be inserted into a normal pulp chamber's secondary dentine, but often can be inserted into a small hole in the center of the cementum of the normal infundibulum. The incisors on a young horse have a single infundibulum (cup) containing cementum. The incisors also have a pulp chamber that can divide into two or more canals and should be filled completely with dentine (dental star).

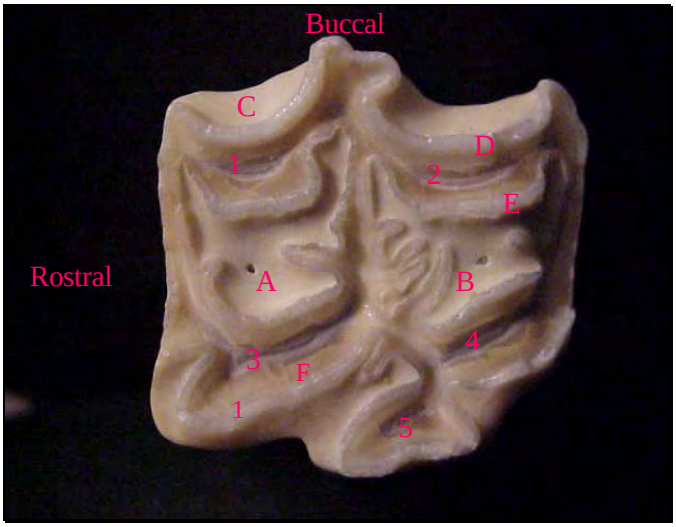

Figure 3. Pulp chambers 1, 2, 3, 4, 5 filled with secondary dentine. Infundibuli A and B filled with cementum with patent central canal. Peripheral cementum C. Enamel folds D and E. Primary dentine F.

A thorough oral examination is necessary to diagnose infundibular decay. A full mouth speculum, bright headlight, dental mirror and fine dental probe are necessary for a proper dental examination. Visual examination will often reveal abnormal food collection in the occlusal surface of the teeth. The occlusal surface of the teeth should be carefully examined visually and with a small probe to look for defects and discoloration or decay of the surface. Damaged or fractured areas on a tooth should be carefully examined to determine if there is communication with the pulp chamber of the tooth. Each pulp chamber should be examined on the incisors and upper and lower cheek teeth. One should not be able to insert a probe into the pulp chamber, as the darkly stained secondary dentine should be intact in a normal tooth. The infundibula of the maxillary cheek teeth should be probed and checked for signs of decay. Observing feed packing in the infundibula on the occlusal surface indicates possible infundibular decay of the maxillary cheek teeth. This food should be cleaned out of the infundibulum to observe the extent of the decay. A dental mirror and incremented periodontal probe are necessary to determine the depth of the decay.

Diseased teeth with pulpar exposure or accidental pulp exposure should be repaired immediately. As an emergency measure, calcium hydroxide paste can be used to seal a damaged pulp. The upper 3 – 4 mm of the pulp canal should be carefully cleaned out with a high-speed drill or small curette. The canal can then be packed with calcium hydroxide powder or paste and a composite filling applied to ensure a proper seal. In the past, visualization of a ‘blush’ or redness to the occlusal surface above a pulp chamber after reduction of a tooth indicated the close proximity of the sensitive pulp and was thought to be acceptable. In many cases the heat created by aggressive reduction of the tooth will severely damage the sensitive pulp, likely leading to the death of the tooth, even without exposing the pulp. Aggressive reduction can also directly expose sensitive dentine, which can lead to inflammation or infection of the sensitive pulp. Once damaged, the sensitive

Figure 4. Occlusal view of decayed pulp chambers of 406 in dental mirror. Open pulp chambers caused by aggressive "bit seat" 4 yrs prior.

Figure 5. Infundibular caries of the rostral infundibulum of 109 and of both infundibula of 110 with coalescence of the latter infundibula.

pulp may not produce secondary dentine to seal the pulp canal. Over time as the existing secondary dentine on the occlusal surface is worn away, the open pulp chamber will be exposed and cause contamination of the interior of the tooth and apical abscess formation. Aggressive reduction of the premolars (creating large 'bit seats') can also cause this damage to the sensitive pulp (Fig. 4). Occasionally, if the damage is not too severe, the pulp chamber may be sealed with tertiary dentine proximal to the damage.

Similar to decay of the infundibulum, decay of open pulp chambers can weaken the tooth and cause fractures of the tooth. In many cases, open pulp chambers and resulting decay can be treated with fillings similar to that described for infundibular decay. To prevent this type of damage, water-cooled, sharp instruments should be used and a conservative approach taken. When tall teeth are reduced, the correction should be done in stages, over several treatments. Treatment intervals can vary from months to years depending on the severity of the condition and the age of the horse.

Most important is the recognition of cemental hypoplasia and infundibular decay (Fig. 5). Young horses may appear to have an enlarged infundibulum, but as the tooth comes into wear, the initial surface is worn away and a normal infundibulum filled with cementum appears (Fig. 6). In the case of a young horse (e.g. less than eight years of age), that does not appear to have a problem, it is useful to re-evaluate the horse in six to twelve months. In the older horse with food packing in the infundibulum, one should clean the majority of the debris out of the infundibulum using a fine dental pick. Air abrasion and a high-speed drill are also very helpful in removing the packed feed and the decayed tooth material. The most important part of filling a tooth is making sure all of the debris and decay is removed by repeated observation with a dental mirror, prior to any filling.

The Equine Dental System by Pacific Equine Dental Institute (P.E.D.I.) offers the advantage of having a prophylaxis/air abrasion unit, which utilizes high-pressure lavage

Fig. 6. Normal cheek teeth infundibula of a young horse. These teeth are not in full occlusion yet.

(100-200psi) with sodium bicarbonate/chlorhexidine solution to clean and disinfect.[b] The system also offers a high-speed drill, sonic scaler, venturi suction and triplex syringe for air and water. A surgical length ball-type of burr can be used for the majority of dental material removal and a smaller fissure type of burr is useful for the intricate infoldings of the infundibulum. Air abrasion with 25-micron diameter aluminum oxide powder at 150-200psi pressure will aid in removing decayed tooth without harming the healthy tooth material. One must allow adequate time to do a complete preparation of the carious infundibula, which involves multiple cleanings, rinses and rechecking with the mirror. The utmost care must be taken not to drill through the enamel of the infundibulum and into the pulp canal or sensitive dentine. Repeated use of a dental mirror will allow removal of only the decayed portion of the tooth.

The base (apical aspect) of the infundibulum often contains red stained cementum which can make it appear as if the blood supply is close, but this discoloration is believed to be hemosiderin staining and connective tissue remnants from tooth development. If one accidentally enters the pulp and bleeding occurs, a dental astringent can be used to stop the bleeding before filling the tooth. The etchant should be used before the astringent or the area will bleed again after etching. Calcium hydroxide paste also can be used effectively to stop bleeding and also acts as a good substrate for the reparative process to begin. Once the decayed portion of the tooth is removed, the area should be rinsed and a phosphoric acid etchant applied for 20 seconds. The etching agent should be rinsed off with water and the area dried with a triplex syringe. A bonding agent is applied and is ultraviolet (UV) light cured for 20 seconds. Next, the composite filling material is applied (Fig. 7).

In the case of large defects, the filling material should be applied in layers and UV light cured between layers. An anodized probe or plugger can be helpful in applying the composite to ensure no voids are left in the defect. A dual cure flowable composite[c] is the agent of choice at this site because this filling will cure, without light activation, no matter how deep the defect. When using a dual cure composite, use a curing light as minimally as possible to help prevent shrinkage of the filling. Undercutting the rim of

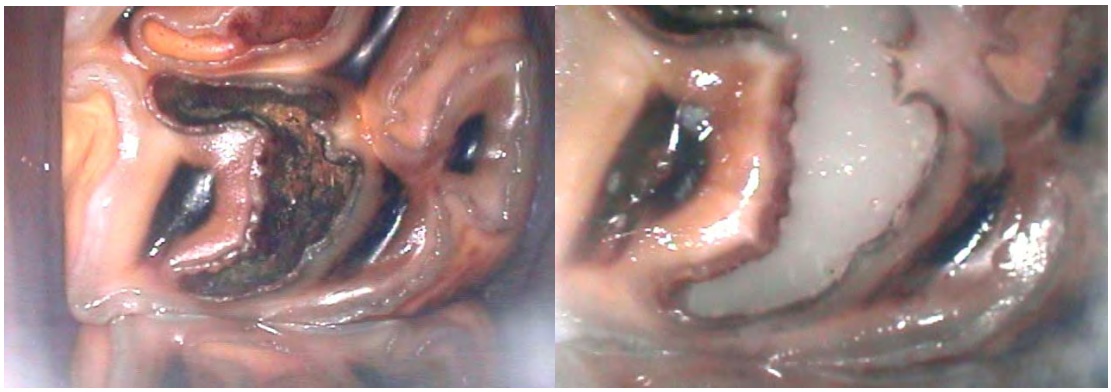

Fig. 7. (Left) Carious infundibulum packed with feed material. (Right) Infundibulum after cleaning out and filling with a modern composite filler.

the defect slightly will give a mechanical advantage in retaining the filling. One must carefully inspect the margins of the filling to ensure a tight seal is present and to prevent micro leakage. A shepherd's hook probe is very useful in finding small defects.

Open pulp canals should be approached in a similar manner. One should drill out the open canal as deep as possible, rechecking frequently with the mirror to make sure the pulp canal is being accurately followed and that the pulp canal has not already been sealed with tertiary dentine. If only one pulp is affected, one should carefully check the remaining areas of dark stained secondary dentine with a fine probe, and also fill these pulp chambers if they are open. These teeth should be rechecked every six months to evaluate the integrity of the filling and check the remaining pulp canals for patentcy. If the tooth is dead, secondary dentine will not fill the remaining pulp canals and they will become exposed as the occlusal surface is worn away. Minimizing the occlusion of the tooth by reducing the opposing tooth can help increase the life of the fillings. Severely diseased teeth will have the pulp horns making up the interior of the tooth completely filled with food material. It is likely impossible to completely clean out these complex dental horns from the occlusal surface. Radiographs including intraoral views can help show details of the structures inside the tooth itself, and are very helpful in determining the integrity of the supporting structures around the tooth.

As with all dental disease, early diagnosis and preventative dental care is the best treatment for infundibular decay. If some cases of infundibular caries are allowed to progress, they may cause extreme discomfort, loss of teeth, and deterioration of the overall health of the horse. Thorough oral examination and treatment with modern instrumentation and methods can greatly improve oral health and extend the useful life of the horse's dentition.

References and Footnotes

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