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## ENDODONTICS – TECHNIQUES AND FUTURE DEVELOPMENTS

### Endodontic therapies

Endodontic means ‘relating to the pulp’. Before any endodontic therapy is planned, the state of vitality or otherwise of the pulp must be considered. Diseased pulp may be inflamed reversibly or irreversibly. Irreversibly inflamed pulp is common due to inflammation within a non-expandable calcified pulp canal resulting in ischaemia and necrosis. Younger teeth with larger pulp canals and wide apices may be better able to respond to insults than older teeth with narrower pulp canals and smaller apical communications through fully formed roots.

### Septic pulpitis

Acute septic pulpitis of cheek teeth is most likely due to anachoresis, subsequent bacterial invasion and further ischaemia resulting in pulp death. As previously described, the pulp may survive by mounting a reparative response, at any point from the level of the pulp insult to the periapex, or the entire pulp system may necrose resulting in continued recurrent apical swelling. In some instances, it appears that the apex closes completely, with resolution of any apical swelling (despite dead necrotic pulp), e.g. Fig.1. These cases can make particularly successful endodontic procedures as the apexification required for successful endodontic therapy appears to have either fully or partially occurred by a combination of apical sclerosis, cementosis and reparative dentine formation. Teeth such as these will develop occlusal pulp exposures over time from continued eruption and surface attrition, now resulting in food influx into the pulp canals. Larger pulp canals in younger horses, with less calcification of the tooth are likely to develop rapid caries, leading to possible pathological fracture. These conclusions and observations still require accurate documentation in further studies despite being previously described<sup>(1)</sup>.

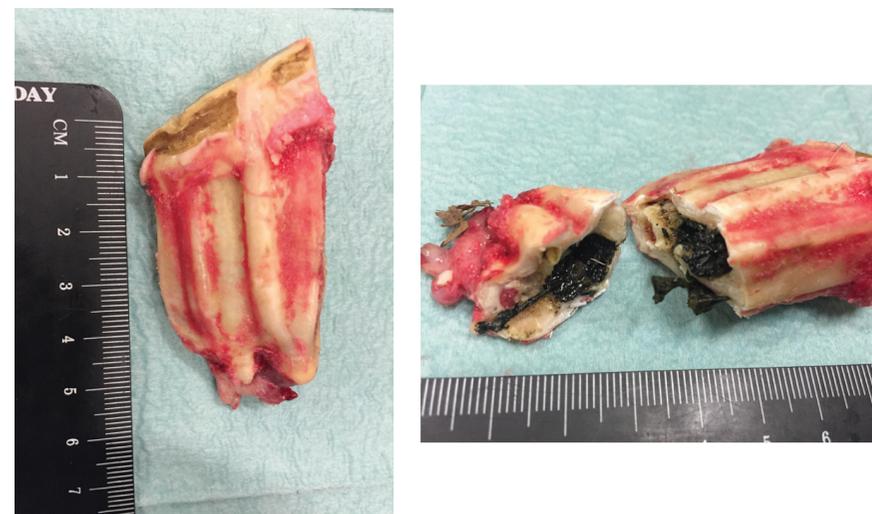


Fig. 1. Orally extracted 106 tooth, complete (left) and sectioned (right). The apical ‘abscess’ apparently resolved by the time of referral, 6 weeks post initial facial swelling. Computed Tomography (CT) imaging showed gas attenuation of all pulp canals. Left: extracted tooth showing apical ‘closure’; right: sectioned tooth showing large communicating non-vital pulp canals incarcerated within the tooth.

### Vital pulp exposure, fractures and consequences

Pulp exposures in horses can occur as a result of iatrogenic trauma, rapid abrasion or dental fracture<sup>(2)</sup>. Iatrogenic pulp exposure is possible during occlusal odontoplasty owing to the variable thickness of sub-occlusal secondary dentin separating the pulp horn from the occlusal surface. Exposure of the vital pulp may also occur through excessive abrasion of the crown through cribbing, or grazing short pasture. If the rate of abrasion of the clinical crown is faster than the ability of the pulp to recede and produce secondary dentine, exposure of the vital pulp will develop. Fractures of teeth can be classified by the tissues involved, and by the cause. Traumatic fractures are more common for incisors and canines, however most cheek tooth fractures are pathological, secondary to existing disease weakening the tooth structure. Classification by structure involved:

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- Uncomplicated crown fracture (UCF)
  - 'Chip' fracture – small fracture of dental margin not involving tissues relating to the pulp (pulp, SO2D)
  - Deeper fracture not involving pulp or SO2D
- Complicated crown fracture (CCF)
  - Fracture through SO2D but not involving vital pulp (2DCCF)
  - Fracture through vital or non-vital pulp (true CCF)
  - Infratubular caries related fracture – will almost always involve vital pulp or apical tissue

If vital pulp exposure occurs there is a small window of opportunity to keep the tooth vital. Successful vital pulp therapy requires the adherence to 3 basic dental principles: treatment of a non-inflamed pulp, application of a pulp dressing, and creation of a bacteria-tight seal. Pulp capping, partial or full pulpotomy can be successfully performed on incisors and canine teeth but these techniques are rarely required or indicated for endodontic treatment of cheek teeth.

Endodontic treatment in the horse can be broken down into the following categories:

### Vital pulp therapies

- Pulp capping
- Partial pulpectomy
- (Full pulpectomy)
- Pulpotomy

### Non-vital pulp therapies

- Occlusal endodontic (root canal) therapy (RCT)
- Pulp restorations
- Retrograde / apical endodontic RCT
  - Surgical apicectomy and retrograde RCT
  - Extraction / extra-corporeal apicectomy and RCT



*Fig. 2. Non-vital pulp exposures of teeth 101 and 201 from abrasive grazing wear ('starvation' paddock); punctate discharging sinus tracts visible exiting attached gingiva (arrows) – K-flex files are being used to initially probe the open pulp canals and begin the instrumenting process.*

### Vital pulp therapy – emergency treatment

For successful treatment of a vital pulp exposure, and prevention of ascending irreversible pulpitis, a seal over sterilized reversibly inflamed pulp must be created, over which a protective restoration may be performed to further protect the seal. A sterile environment is required for the initial vital pulp therapy. Vital pulp therapy has a high rate of success (95%) in humans and dogs if these principles are followed.

Vital pulp therapies include:

- Pulp capping - direct application of a pulp dressing onto acutely exposed non-inflamed pulp with minimal restoration. Pulp capping is used in emergency situations to save the vital pulp and encourage a secondary dentine seal to provide longer-term survival of the deeper pulp.
- Partial pulpectomy - removal of (irreversibly) inflamed pulp, with application of a pulp dressing and restoration. Treatment of choice for most vital pulp therapy, e.g. acute fractures .
- Complete pulpectomy - complete removal of all pulp tissue to the apex with subsequent full pulp and root canal obturation; suitable for more chronic septic pulpitis (e.g. Fig. 2)

Previous papers have described the above techniques in detail <sup>(2,3)</sup>.

### Non-vital pulp therapy

For longer standing complicated crown fractures, or for apical abscessation, the pulp will be non-vital. For cheek teeth, due to pulpar separation, there may be a combination of vital and non-vital pulp in the same tooth. Also, there may be occlusal exposure of the non-vital pulp through continued attrition and eruption (as above) resulting in occlusal dentine fissure (non-vital pulp exposure, NVPE). In such cases secondary caries is inevitable as the pulp canal becomes filled with food material from the exposed occlusal defect. There may or may not be apical abscessation, depending on osteoblastic activity apically sealing the pulp / tooth apex. If there is no apical abscessation, due to reparative dentine formation and apical cementosis, the treatment is better termed a *pulp restoration* and treatment may prevent further caries and eventual pathological fracture.

Orthograde endodontic therapy for equine incisors has been reported, but a scientific study documenting long-term success beyond 18 months is unavailable. The author has been using a technique for incisor pulp canal therapy based on a two-stage procedure as follows, with good success with 47 cases over 3 years. The technique is that described by Lundstrom <sup>(4)</sup> and can be used for both pulp restoration and root canal therapy in incisors, canines and cheek teeth:

1. Access occlusal (non-vital) pulp
2. Remove necrotic pulp debris, impacted food material, carious dentine using endodontic file instrumentation
3. Radiograph to ensure apical access and determine 'working length' (depth to apex, Fig. 5)
4. Flush canal 5% sodium hypochlorite or 'Dakin's' solution (care not to extend beyond apex)
5. Flush canal copiously saline with fluid pump and spinal needle
6. Evacuate pulp canal using suction, dry with paper points
7. Place calcium hydroxide paste to apex using Lentulo spiral filler
8. Place temporary occlusal cement sealant (e.g. 'Provicol')
9. Re-treat at 4-8 weeks, re-instrument, flush, dry
10. Obturate entire pulp canal using mineral trioxide aggregate (MTA) cement (e.g. 'ProRoot' or 'Biodentine'), or self-etching self-bonding wetbond resin cement (e.g. 'Embrace')
11. Follow-up radiographic examinations at +3, 9, 18, 36 months.

Treatment by this method for cheek teeth represents a considerable technical challenge for practitioners and is best reserved for longer term training through a residency programme.

Retrograde endodontic treatment of equine teeth may logically a preferred approach considering the 'upside down' nature of the pulp system. Accessing the tooth from the apex results in simplified removal of the pulp and a technique more similar to orthograde root canal treatment in brachydont teeth. Various techniques and results have been described, with success has been evaluated from 3 to 49 months postoperatively depending on the tooth <sup>(5)</sup>. Of 17 teeth treated in this manner, 35% needed extraction, 17% had continued periodontitis, and 47% were considered successful. A major complication encountered in the previous study was eventual exposure of the soft endodontic obturation materials resulting from occlusal wear. These materials quickly deteriorated, and the exposed pulp cavity became contaminated with feed. Feed contamination led to further deterioration of the tooth's structural integrity. This problem can be countered as above by the use of hard-setting

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novel obturation materials e.g. mineral trioxide aggregate (MTA). The author has used this successfully in 3 cases of standing surgical apicectomies in maxillary 07 teeth with 66% success with 4-year follow-up including computed tomography assessment at 4 years post procedure (unpublished findings).

A complication of endodontic therapy (full root canal therapy) is that the tooth becomes slowly demineralised and becoming increasingly fragile, with possible dental fracturing and/or crumbling. The author has noted this with orthograde treated cheek teeth as a major complication especially in young horses.

An alternative method of retrograde root canal therapy for cheek teeth has recently been utilized (Stoll, Pearce, unpublished cases). In this technique, the apicectomy and retrograde root canal therapy are performed after extraction of the affected cheek tooth, with the tooth subsequently replanted in the alveolar socket after pulp therapy. Recent studies of the periodontium have demonstrated a remarkable capacity for repair<sup>(6)</sup>, and developmental studies show a capacity for the alveolar ligament to attach to inert enamel, giving this treatment potential credibility. To date the author has performed 27 procedures with 4-year follow-up with 82% success. Many cases have remarkably shown no ill effects at all with all presenting signs resolving within 3-6 months (facial swellings, discharging tracts). Radiographs can demonstrate apparent successful replantation and the teeth have been observed to erupt and wear normally. Careful case selection is required, and meticulous follow-up must be performed to demonstrate normal mastication, occlusal wear and future stability of the tooth but currently this novel treatment appears to have promise for the future but is currently critically invalidated.

Other methods for cleaning and sterilizing the pulp canals utilised in human dentistry that may be of use for the future include laser therapy of pulp using techniques such as photon induced photoacoustic streaming (PIPS) and shockwave enhance emission photoacoustic streaming (SWEEPS) using an Erbium-Yag dental laser. These techniques may provide a more effective method of access and sterilizing deep pulp canals that are not easily reached by conventional files in long pulp canals.

Mineral trioxide aggregate (MTA) and other analogues ('bioceramics') appear to be promising obturation materials for the future as they are relatively easy to place, have a high pH which is bactericidal, induce apical cementosis, reparative dentine formation and have good wear resistance at the occlusal surface.

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