Veterinary
Instrumentation

Surgery Guide

Dental Extraction Techniques

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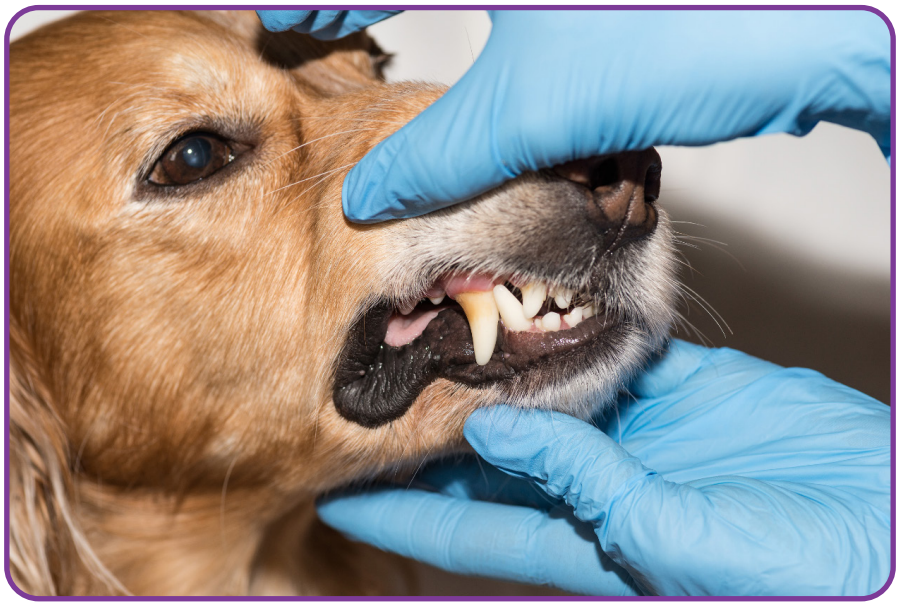


Extraction of teeth is one of the most commonly performed surgical procedures by general practitioners but can be the source of significant frustration, and potential for complication and complaint. A clear understanding of the relevant anatomy, carrying out individualised case-based planning and having an understanding of how to perform extraction techniques, can eliminate significant stress for the clinician as well as markedly improving patient outcomes.

Contents

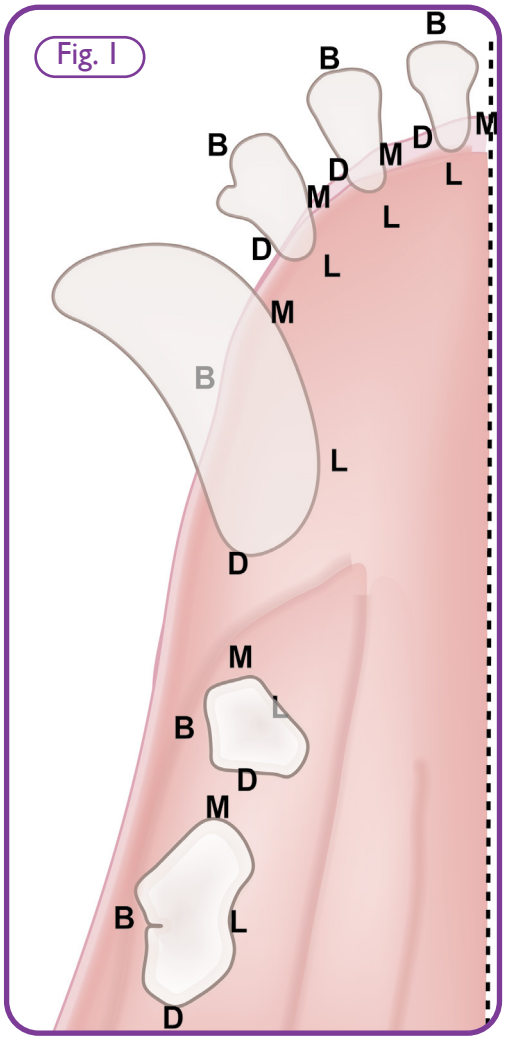
Directional descriptors

The ability to accurately communicate and record positional information is fundamental to medical practice. There are specific conventions of direction used in descriptions of structures of the oral cavity. The usual term 'cranial' to denote toward the front is redundant as all tissues could be described as cranial; instead 'rostral' indicates toward the front of the cavity, and 'caudal' toward the rear of the cavity.

Directional descriptors for pairs of teeth (Fig. 1) are as follows:

- **M**esial: the surface of the 1st incisor tooth which faces the sagittal midline, or the surface of all other teeth which face the 1st incisor tooth.
- **D**istal: the opposing surface to the mesial.
- Vestibular/**B**uccal: the surface of the tooth toward the lips or cheek.
- **L**ingual/Palatal: the opposing surface to vestibular/buccal.
- Coronal: towards the crown of the tooth.
- Apical: toward the apex of the root.

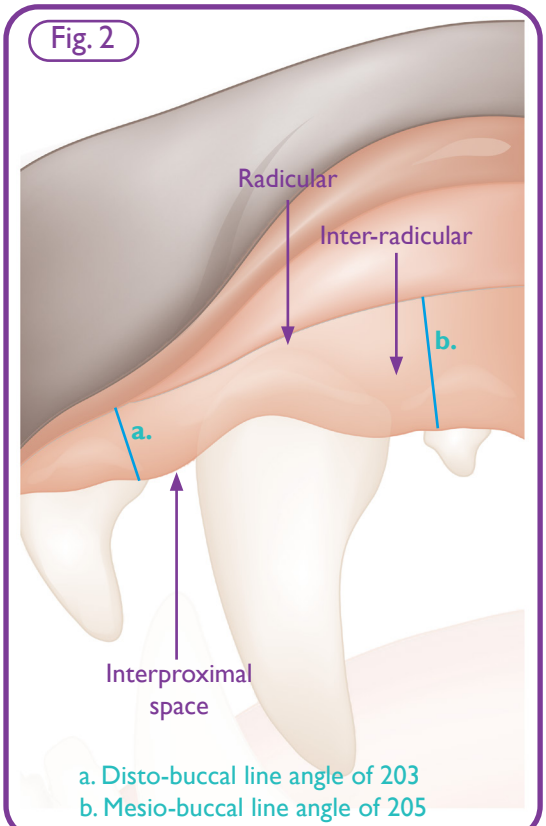
Fig. 1



Other descriptive terms (Fig. 2) commonly used in oral surgery:

- Interproximal: the space between two teeth.
- Radicular/ interradicular: the area around a tooth root/ between roots of multi-rooted teeth.
- Line angle: the point where two adjacent curved surfaces meet, such as the mesial and buccal surface of a tooth.

Fig. 2



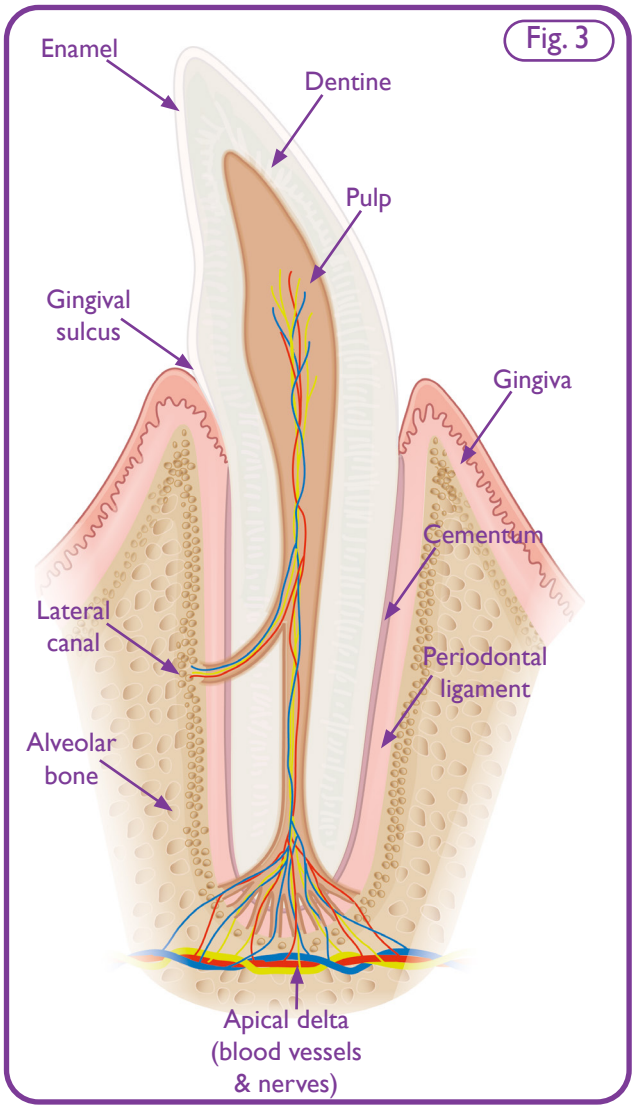
a. Disto-buccal line angle of 203
b. Mesio-buccal line angle of 205

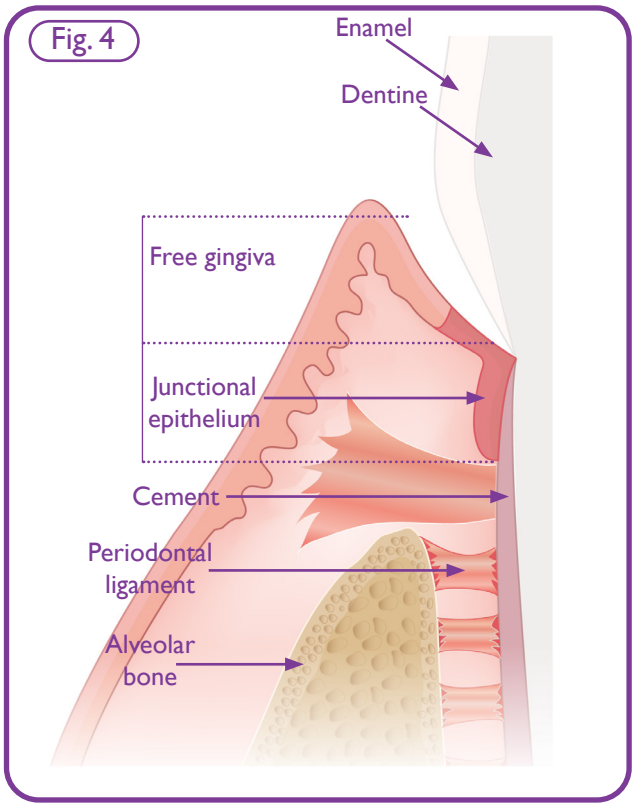
Dental & periodontal anatomy

The oral cavity is lined with squamous epithelium and can be divided into gingiva and mucosa. This tissue is biologically active, with continuous division and desquamation. This functions as a component of oral defence against formation of plaque, as the individual cells are lost carrying away parts of the biofilm during mastication. The division between gingiva and mucosa is visually evident; the muco-gingival junction. The oral mucosa is loosely attached to the underlying bone and is generally non-keratinised, except that of the palate.

Fig. 3 (overleaf) illustrates the anatomy of a tooth.

Fig.4 (overleaf) illustrates in more detail the cement-enamel junction/alveolar ridge and gingiva, up to the level of the muco-gingival junction.





Gingiva

- Junctional: the non-keratinised attachment to the tooth at the floor of the sulcus. These cells actively synthesize the molecules involved in defense against bacteria.
- Sulcular: the non-keratinised epithelium that lines the gingival sulcus and apically meets the junctional epithelium, terminating coronally at the free margin.

Sulcar depth ≤2mm dog and ≤0.5mm cat. Gentle use of a graduated periodontal probe allows measurement.

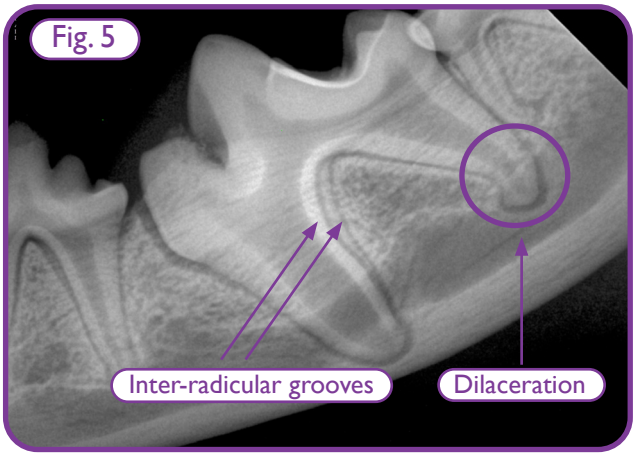
- Free: the keratinised epithelium, beginning from the free margin and facing the oral cavity, terminating at the alveolar ridge.
- Attached: the keratinised epithelium, beginning at the alveolar ridge and extending to the muco-ginigival junction; it is firmly adherent to underlying bone. This distance is equal to the biologic width; human studies indicate that if this width is <2mm, the long term prognosis for tooth preservation is poor.

Periodontium

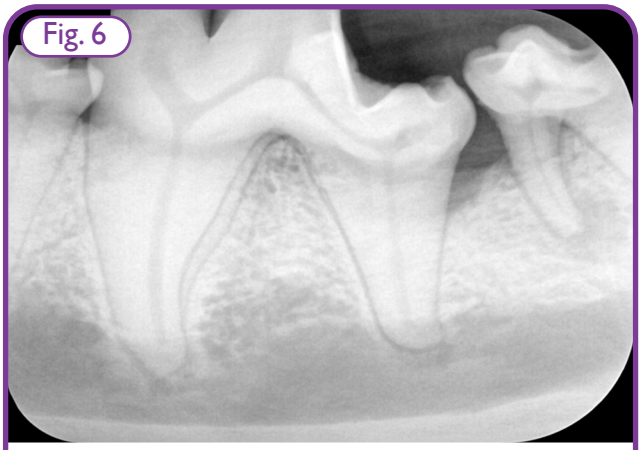
- The specialised tissues that support and hold the tooth within the oral cavity.
- Alveolar bone: formed from the alveolar process of the jaw bone; a depression or hollow in which the tooth roots sit. The cavity has a dense lamellar bone lining supported by trabecular bone. The combination of lamellar and trabecular bone gives strength and flexibility.
- Periodontal ligament (PDL): composed of fibres originating from the lamellar bone of the alveolus and inserting into the cement of the root.
- Suspensory ligament: tolerates the compressive forces of mastication whilst minimising damage to the tooth. Evolved to tolerate high forces of short duration (ie. Chewing).
- Cells within the PDL: the epithelial rests of Malassez (ERM) are likely important in maintenance of cement and PDL health and signaling osteoclasts. The ERM have the ability to divide into multiple cell lineages, similar to stem cells.
- Cementum: mineral content similar to dentine but has the ability to repair. The cementum is firmly adherent to the underlying dentine.
- The PDL insertion via Sharpe's fibres.

Tooth

- Divided into crown and root, which meet at the cement-enamel junction. This usually corresponds to the neck of the tooth, which is a constriction in tooth diameter visible radiographically.
- Multi-rooted teeth have a furcation where the roots and the crown meet; two-rooted teeth have a singular furcation and three-rooted teeth have two furcations. Bone should fill the entirety of the furcation and exposure of the furcation is a poor prognostic indicator for tooth preservation.
- Deviation of the root along its length is referred to as a dilaceration. (Fig. 5). Dilaceration will have a significant impact on extraction due to the formation of a stress riser at the most apical point of the inner surface of the curve. The extraction pathway of a tooth follows the line of the root; if a dilaceration is present, the extraction pathway will be curved.



- Infolding on the root surface (Fig.6) may be appreciated as a twinned periodontal ligament space on dental radiographs and represent an invagination of the root with a corresponding "key" of alveolar bone, which mechanically resists rotational forces. This is common in the mandibular 1st molar teeth of large breed dogs. Identification of their presence should lead to adjustment of technique.



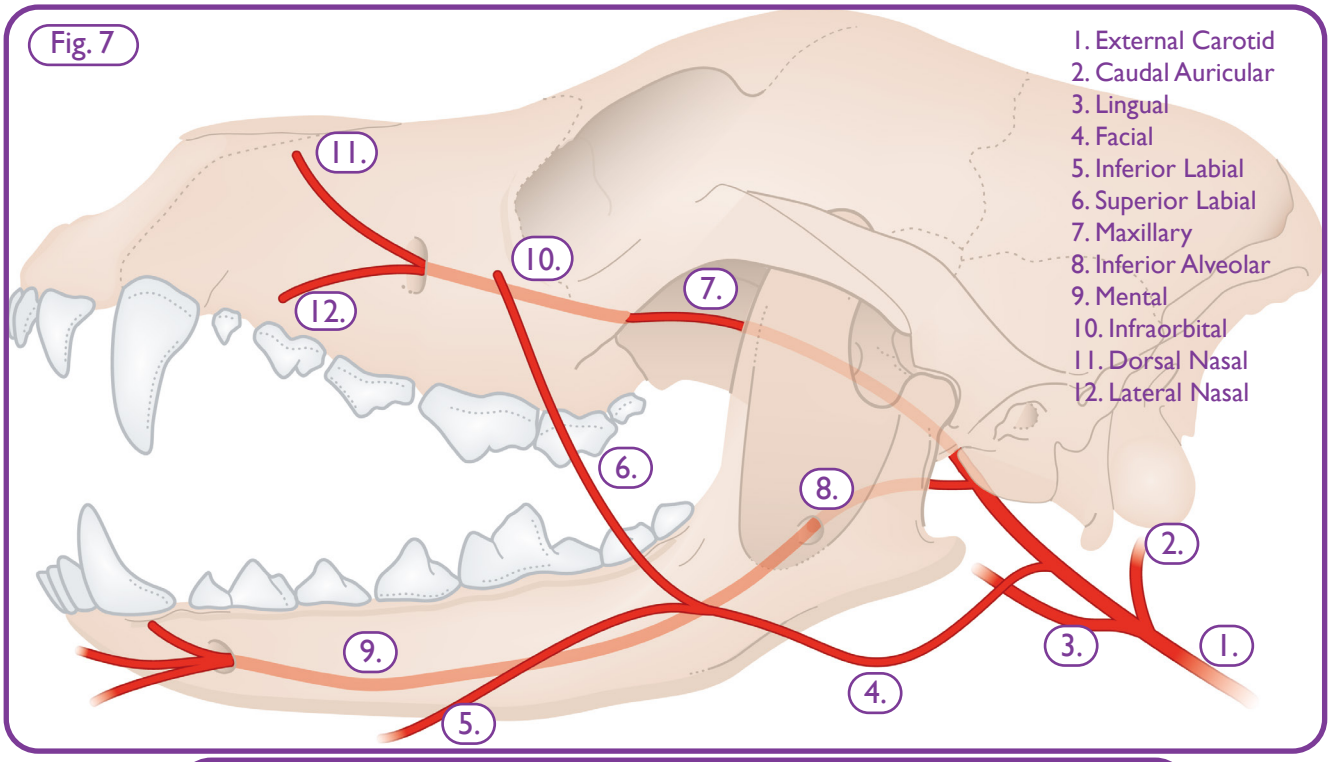
Mature, permanent left mandibular molar tooth. The dentinal walls are thick and the root canals relatively narrow, as would be expected in an older dog.

- The tooth is hollow, with a continuous chamber in the crown and root filled with sensitive pulp.
  - Crown: pulp chamber
  - Root: root canal
- These chambers progressively narrow over time due to the continual deposition of dentine on the internal surface of the chamber. This deposition may speed up if there is chronic inflammation or stop if the pulp's vitality is lost.
- Pulp contains un-myelinated nerve fibres (C fibres) which conduct pain sensation. The C fibres have their axonal bodies outside of the pulp and are resistant to hypoxia, meaning pain propagation persists for some time after pulp necrosis.

Facial anatomy for the oral surgeon

An understanding of the course of the neuro-vascular tissues of the head (Fig. 7) is important to give the oral surgeon confidence when performing extractions and to prevent complications.

Fig. 7



NB. The veins and nerves commonly run adjacent to the arteries, especially though the mandibular and infra-orbital canals.

- The common carotid artery divides into the external carotid (EC) and internal components, with the EC supplying the dental and facial tissues, hence their excellent blood supply.
- Branches of the EC are the lingual, facial, mental and posterior auricular, with the remainder forming the maxillary artery.
- The facial and mental arteries course behind, and on, the lingual surface of the temporo-mandibular joint and ramus, with the mental entering the mandibular canal and becoming the inferior alveolar vessel, with a paired vein and associated nerve.
- The mandibular canal in dogs less than 15kg commonly courses adjacent to the roots of the mandibular 1st molar tooth, and not below the apex.
- 82% of canals course on the buccal aspect. This is an important consideration in extraction if extensive bone removal (alveolectomy) is indicated.
- The inferior alveolar artery exits the mandibular canal at the caudal, middle and rostral mental foramina. The middle mental foramen is found on the buccal surface of the mandible, level with the apex of the mesial root of the mandibular 2nd premolar tooth.
- The facial artery loops under the mandible, level with the junction between the mandibular body and the ramus, and courses in the cheek rostrally and dorsally.
- The maxillary artery anastomoses with the rete mirabile then crosses the pterygoid fossa/ retrobulbar space to enter the infra-orbital canal below the eye, becoming the superior alveolar artery.
- The maxillary artery, via the rete mirabile, provides a significant supply of blood to the brain. This is especially important in cats as there is a poor collateral supply. Prolonged occlusion which occurs on wide mouth opening (such as during dental procedures) can result in ischaemic brain injuries, commonly resulting in deafness, blindness and post-operative seizures.
- The superior alveolar artery leaves the infra-orbital canal via a foramen level with the mesial root or furcation of the maxillary 3rd premolar tooth, which is palpable. This canal normally courses above the level of the apex of the maxillary 4th premolar tooth roots. In brachycephalic breeds, the course of the canal may be inter-proximal between mesio-buccal and mesio-distal roots, influencing bone removal during extraction.

The dog and cat have paired mandibles with a fibrous joint at the rostral limit. (There is no such structure as a hemi-mandible in cats and dogs). Radiographically, there is a clear lucency at the symphysis (Fig.8) and some laxity is commonly appreciated, especially in older cats, and should be considered a normal finding.


Fig. 8

Extraction planning

Dental radiography should be considered vital when undertaking dental diagnostics and subsequent treatment planning.


Fig. 9

Image courtesy of Midmark

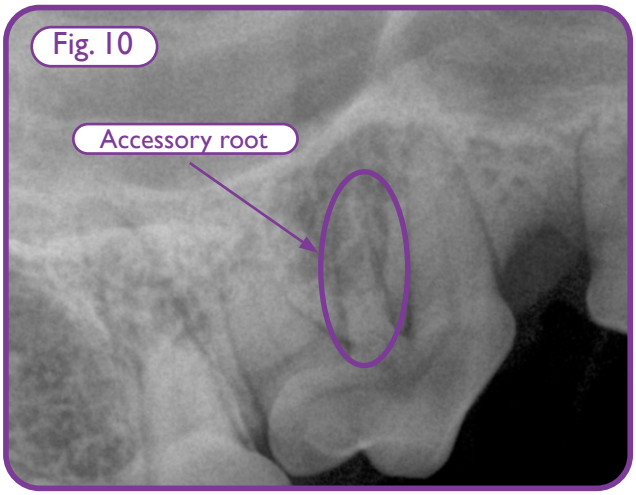
Dental radiographs should be considered vital when undertaking dental diagnostics and subsequent treatment planning. This is due to our inability to assess the sub-gingival tissues effectively though any other means. The sub-gingival tissues are those most commonly involved in pathological process and have the greatest influence on success, or otherwise, of extraction. Although conventional radiology can be used to acquire images of the dentition, such images commonly fail to provide sufficient detail to make an accurate diagnosis.

Following radiographs the surgeon should:

- Evaluate the diagnostic quality of the images.
- Review normal anatomical features.
- Identify accessory roots if present. (Fig.10).

10% of all maxillary 3rd premolar teeth in cats have three roots.

- Identify pathology. Where pathology has resulted in significant structural weakness, discussion with the owner prior to treatment is wise, in order to manage owner expectations.



Where extraction is necessary:

- Consider how the individual distribution of pathology may affect technique, or where adjustment of technique may improve outcome.
- In the case of resorption, there may be a significant weakness of the root which will result in root fracture under loading. Exposure of the root below this weakness point may be necessary.
- Removal of the "key" of bone from radicular grooves may be necessary to facilitate extraction.
- Bone removal below the level of the curvature of a dilaceration may be required to prevent root fracture.
- Identify the extraction pathway; this is a continuation of the line of the root. Many tooth roots are curved, such as the maxillary 3rd incisor tooth, and may require extraction forces to be exerted in line with this curvature (often palatally, in the case of the 3rd incisor).
- For multi-rooted teeth, consider the order of operation to achieve successful extraction. Anatomical features may mean that one root must be extracted before another, to facilitate extraction along the extraction pathway.

Principles of extraction

The primary goal of extraction is to remove the entirety of the tooth with as little impact on adjacent tissues as possible. This is achieved by application of strategic mechanical forces that overcome the inherent retentive strength of the PDL. Forces may be exerted directly or via leverage, but leverage does risk damage to adjacent tissues if not performed circumspectly. The periodontal ligament is adapted to resist high force short duration (chewing). Therefore, when exerting force to extract, this must be done over a prolonged time period; the author recommends 15-20 seconds.

Extraction forces can be exerted directly to the PDL through simple grasping of the coronal root by forceps, and pulling. The long, relatively fragile roots of cat and dog teeth commonly undergo structural failure prior to mechanical overload of the PDL, resulting in incomplete extraction. Overload of the PDL is best done either by severing the fibres of the PDL or tearing them, prior to exerting an extraction force. The surface area of PDL may be reduced by removal of alveolar wall and the attached PDL, thus reducing its retentive capacity and reducing the force required to extract.

Forces may be applied through wedging or levering (rotational/ prising) movements of instruments, commonly inserted into the PDL parallel to the root surface with the instrument's tip directed toward the root apex. Inappropriate direction of the instrument is a common cause of root fracture. The force results in displacement of the tooth in the alveolus, causing a tension zone in the PDL adjacent to the instrument and a compression zone on the opposing surface of the root. Crushing and tearing of the PDL through compression and tension will occur, with inter-ligament haemorrhage also exerting hydrostatic forces, which will further separate ligament fibres. Changing the point of application of force around the circumference of the tooth results in compression and tension around the root of the tooth.

The periodontal ligament is partly elastic, and a primary skill of extraction is for the surgeon to identify the elastic limit of deflection when applying force to the tooth. Permanent ligament deformation will occur if the force is held between the elastic limit of the PDL and the mechanical failure point of the root.

Repeated practice and appreciation of the deflection level, and correlation with the pre-identified pathology potentially reducing the root mechanical strength, guides the surgeon inspection of extraction type (with or without bone removal), application of force and speed of extraction.

Figs. 11a, b, c and d (facing page) illustrate different ways in which an instrument may be used to displace the tooth in the alveolus, causing tension and compression zones in the PDL.
Fig. 11a: Wedge effect.
Fig. 11b: Pry bar effect.
Fig. 11c: Rotational effect.
Fig. 11d. Wheel and axel effect.

Multi-rooted teeth should be separated in single root/crown components so that force can be targeted on a single root. Sectioning is performed using a taper cut high speed bur (Fig. 12) such as a 699 (cat) or 700L (small dog) or 701L (large dog). Sectioning of the crown through the furcation will achieve individual root/crown components. Accurate and complete sectioning through the furcation is important to avoid iatrogenic tooth fracture under loading. Visualisation by creating an envelope flap is useful.


Fig. 12

Strategic removal of crown may also be indicated to achieve a straight-line insertion of the extraction instrument toward the root apex. The added benefit is that, in teeth with inter proximal contact (such as mandibular molar teeth), this removal of crown will create space for the displacement of the root/ crown component within the alveolus, which would otherwise be prevented by the contact point.

Figs. 13a and b (facing page) demonstrate strategic removal of crown at mandibular M1 - in the second image, the distal cusp of the tooth has been resected, to allow for root movement and straight-line access.

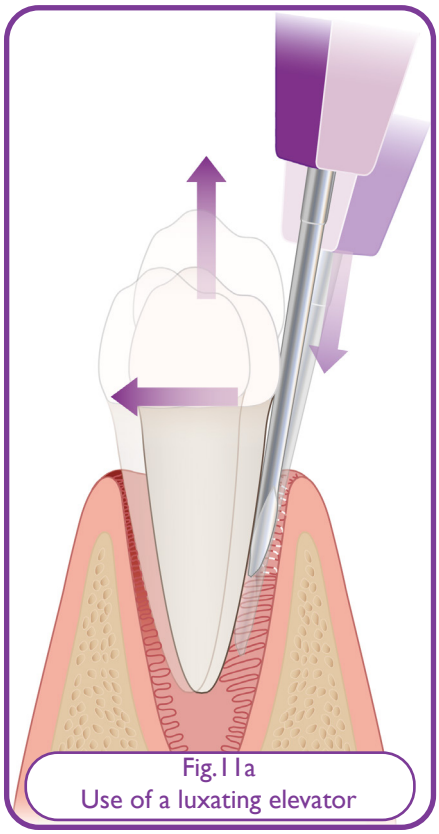


Fig.11a
Use of a luxating elevator

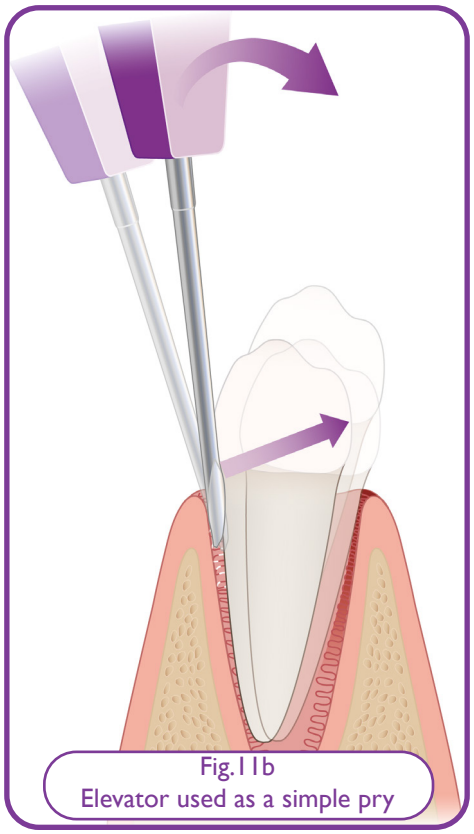


Fig.11b
Elevator used as a simple pry

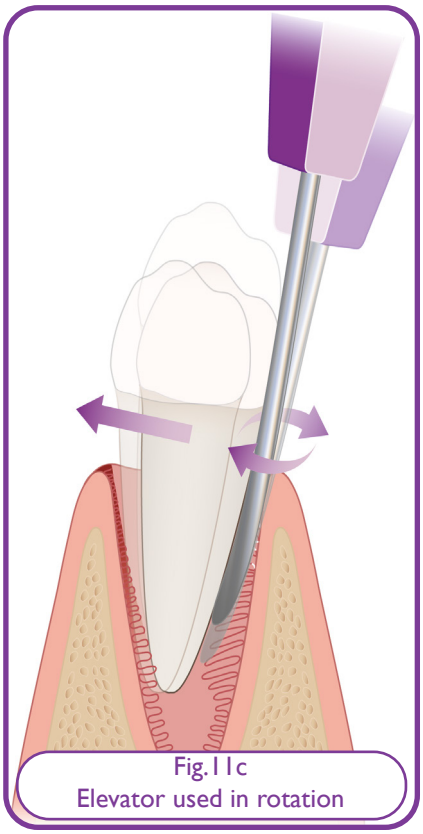


Fig.11c
Elevator used in rotation

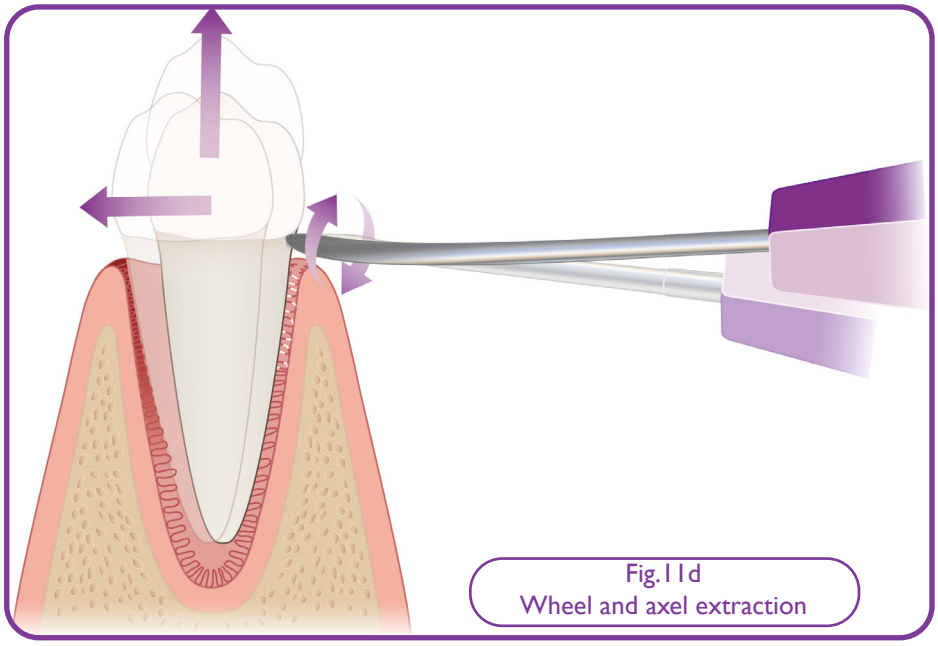


Fig.11d
Wheel and axel extraction

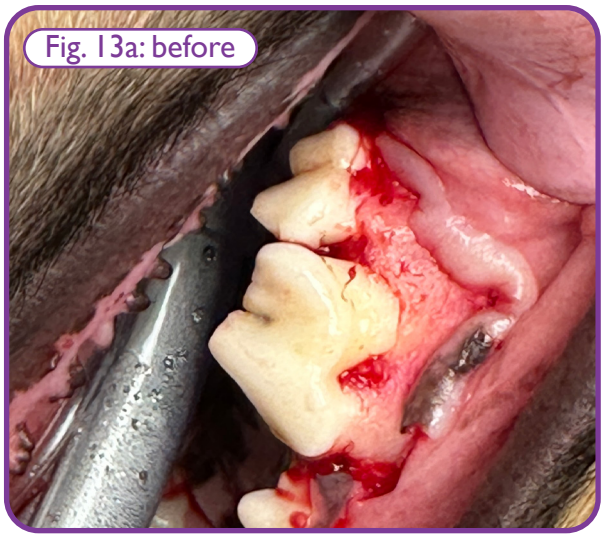


Fig. 13a: before

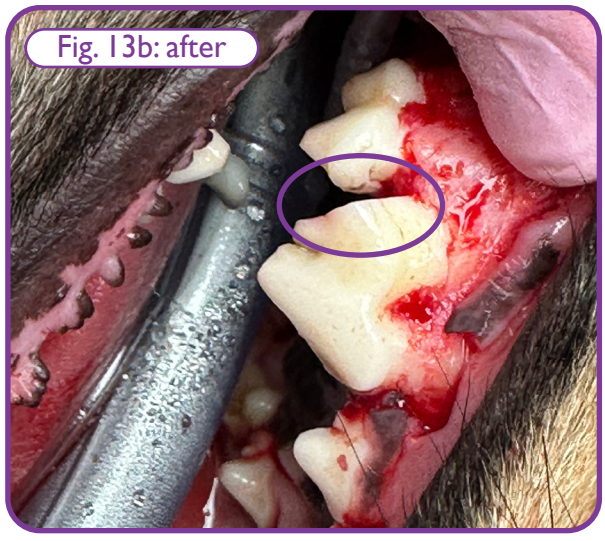
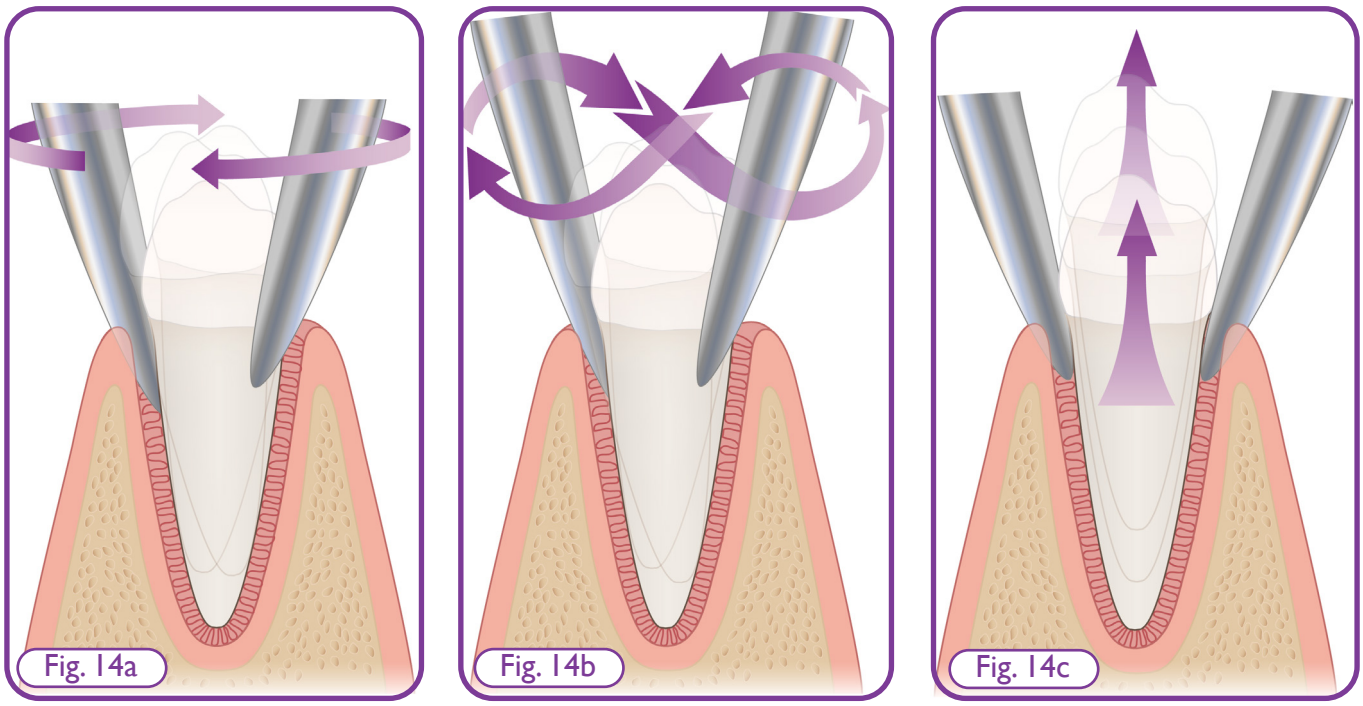


Fig. 13b: after

Once the PDL of the tooth is sufficiently weakened, evidenced by high levels of mobility of the tooth within the alveolus, extraction forces can be applied via use of extraction forceps. Forceps should be placed on the root, not the crown. Initial force should be a figure of eight or rotation around the long axis of the root (rotation held just beyond elastic limit for extended period and then reversed), prior to pulling the root along its extraction pathway. Care should be taken not to lever over the alveolar margin, as this will result in structural failure of the root immediately below the alveolar margin. Forceps should be sized according to application; large, small and the very-useful root tip forceps, the latter used for extraction of root fragments.

Figs. 14a, b, and c illustrate the progressive ways in which the extraction forceps may be applied to the tooth root to achieve extraction, once the PDL has been broken down as previously described.

Fig. 14a: Rotation with extraction forceps, held for a 10 second pause at the end point of rotation before reversing the direction.
Fig. 14b: Dynamic figure of 8 rotation.
Fig. 14c: Application of traction in line with the extraction pathway.



Instruments used for force exertion

The luxating elevator (luxator) (Fig. 15) is a razor-sharp, thin-tipped wedging instrument inserted into the PDL. This instrument is used with a horizontal rocking movement whilst pressure is maintained toward the apex. The result is that the periodontal ligament is cut and a wedging force is created. This is particularly useful for wide periodontal ligaments such as those found in younger patients, or to initially widen the PDL space prior to using a more robust elevator. The luxating elevator (luxator) is a fine instrument and is at risk of damage if used incorrectly. It is not to be used in a prying or twisting motion. It will blunt quickly and sharpening before each use is appropriate and recommended.

The Coupland elevator (Fig. 16) and the winged elevator (Fig. 17) are the most common elevators, with a thicker, more robust chisel-shaped working tip. This instrument is used by seating it into the periodontal ligament with a "wrist rock". It can be used as a prying lever, or with rotation, to achieve displacement of the root. It can also be used in a wheel and axle manner, where the instrument is directed horizontally across the alveolus with the edge of the instrument engaging the neck of the tooth. This technique both displaces the tooth in the alveolus, and also creates an avulsive force out of the alveolus. Very high forces can be generated so fingertip manipulation only is appropriate. This instrument is particularly useful for the distal root of the maxillary 4th premolar and distal root of mandibular 1st molar.

Fig. 15

Fig. 16

Fig. 17

Surgical extraction

Simple extraction does not involve any removal of bone and only the techniques noted above. Bone removal is believed to be a significant factor in post-operative pain development. Bone removal is performed when the root surface area is low and the root relatively robust (eg. the palatal root of the maxillary 1st molar of the dog, or dog incisor teeth) or where there is significant pathology present and the PDL is already weakened. If performed on unsuitable teeth, bone removal may result in excess damage to surrounding bone, also resulting in post-operative pain or root fracture.

Surgical extraction involves excision of part of the alveolar bone wall, commonly the buccal surface, exposing the underlying root and removing the periodontal ligament of that portion of the root.

Bone removal is referred to as alveolectomy, the principle of which is illustrated in Fig. 18. The outline of the tooth root is shown in black, and the shaded area indicates the extent of the alveolectomy.

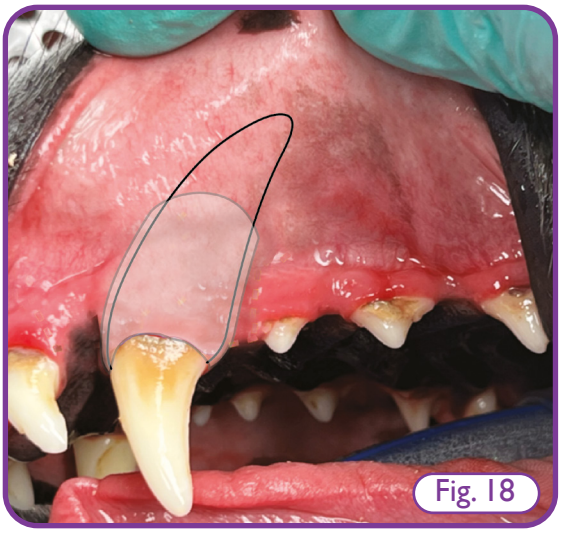


Fig. 18

The bone overlying the root (juga) is exposed by elevation of a mucoperiosteal flap. An initial alveolectomy to 50% of root height is performed; This can be extended significantly if indicated but care must be taken with adjacent neuromuscular structures. If movement of the root is not evident within 3- 5 minutes of attempted extraction, the alveolectomy can be extended to increase the mechanical advantage over the PDL. It is important not to gouge into the root and weaken it. It is common to create "grooves" at the mesial and distal limits of the tooth, to the full depth of the tooth from the mesiobuccal to the mesiopalatal/lingual surface. This further decreases PDL resistance and allows easy insertion/seating of the elevator to apply extraction force.

Click here to watch a short video demonstrating the principles described above.

Extraction Procedure

Order of operation for extraction:

- Consider any adjustment to standard technique based on individual anatomy or pathology.
- Decide extraction type (surgical or simple).
- Perform circumferential incision though the junctional gingiva.
  - (Design mucoperiosteal flap, if a surgical extraction is intended).
  - (Extend incision interproximally/around the adjacent teeth, if also to be extracted).
- Elevate envelope flap, triangle or pedicle flap.
- Perform alveolectomy.
- Extract tooth.
- Perform alveoplasty.
- Debride and irrigate extraction site.
- Close soft tissues.

Circumferential incision should always be performed. This reduces tearing of soft tissues during extraction and reduces risk of slipping during insertion of elevator into PDL, as the tip of the instrument does not skate when tearing through the junctional gingiva. It is possible to elevate around the tooth to create a simple envelope flap, using a periosteal elevator held in a modified palm grip with a high elbow and straight wrist. This concentrates the force on the tip and reduces slipping and tearing of tissues. The periosteal elevator is used in a "turning over" motion rather than simply pushing forward.

Extension of the elevation beyond the muco-gingival junction will result in the flap closing the extraction wound without tension. Following elevation of the envelope, it will be possible to clearly identify the position of the furcation for accurate sectioning. The author prefers to use an SM64 Beaver blade as they are delicate, yet very stiff. The blade can be used as a micro-periosteal elevator to start the elevation of the flap, prior to use of periosteal elevator. Applying the blade to the surface of tooth at approximately 30 degrees internal bevel will limit slipping, and high pressure whilst cutting is preferable to ensure that the cut is completed in a single pass.

Click here to watch a short video demonstrating the use of a small blade as described above.

Mucoperiosteal flap design

Mucoperiosteal flaps (Mc-P) may be simple envelopes as described above, triangular or pedicle in shape. Each subset may also be described as extended if more than one tooth is involved in a single flap. Mc-P are composite flaps with mucosa adherent and overlying the periosteum. Mucosa is extensible whereas periosteum is not.

Achieving tension free closure is critical to successful wound healing in oral tissues.

Selective sectioning of the periosteum will free the mucosa to stretch, allowing a tension free closure. This can be achieved by careful sharp dissection with a scalpel or, in the authors' preference, curved supercut mini-Metzenbaum scissors.

Mc-P flap design should comply with five key principles:

- Allow full access to the entirety of the root surface if needed.
- Following alveolectomy, there is bone remaining under the releasing incisions to support the suture line. The flap must therefore be larger than the planned alveolectomy.
- Avoid un-necessary trauma to adjacent teeth. When Mc-P are elevated, there will be alveolar ridge recession. Elevation of flaps over healthy teeth are to be avoided where possible and releasing incisions should be made at the line angle of the adjacent tooth.
- Do not perform release at the furcation of an adjacent tooth as this will increase the risk of furcation exposure significantly. Releasing incisions must pass beyond the muco-gingival junction into the mucosa for the flap to become extensible and allow tension free closure.
- Releasing incisions should be made perpendicular to the gingival margin to the muco-gingival junction. Once incision is extended to mucosa the incision should diverge from perpendicular to achieve a wide based flap. Perpendicular release allows symmetrical blood supply to the corners of the flap and minimises risk of ischaemic necrosis.

Where possible triangular Mc-P are preferred with only a single releasing incision to minimise gingival recession. Try to avoid releasing incisions overlying healthy strategically important teeth where possible, such as canine teeth, maxillary 4th premolar and 1st molar teeth and mandibular 1st molar teeth. Triangular flaps may be utilised for premolar and molar teeth, maxillary and mandibular canine teeth in cats. Pedicle flaps should be reserved for instances where maximal exposure is required, such as maxillary and mandibular canine teeth in dogs or for closure of oro-nasal fistula.

Mc-P flaps can be injured during elevation. Small tears and punctate injuries in dogs should be closed or excised. Crush injuries should be debrided to prevent a focus for dehiscence. Larger tears, injury to flaps in cats or inadvertent maceration should result in flap excision and creation of a partial thickness advancement flap. Mucosal tissue can be recruited to the level of the muco-cutaneous junction, and include all of the vestibular mucosa where necessary.

Alveolectomy

Alveolectomy (Fig. 19) is performed by using a round tungsten carbide bur in a high speed or low speed handpiece.

- Large dogs: initial alveolectomy performed with a size 4 or 6 round bur with refinement of the margins and creation of mesial and distal channels with a size 2.
- Small dogs and cats: alveolectomy may start with a size 2 bur, followed by use of a half-round to refine the margins.

Alveolectomy begins in most cases with removal of 50-60% of the buccal alveolar bone. Avoid sharp corners to bone removal as this will concentrate stress and could increase the risk of fracture at this point. Additional bone can be removed if there is no dental movement following a reasonable period (3-5 minutes) of attempted removal.

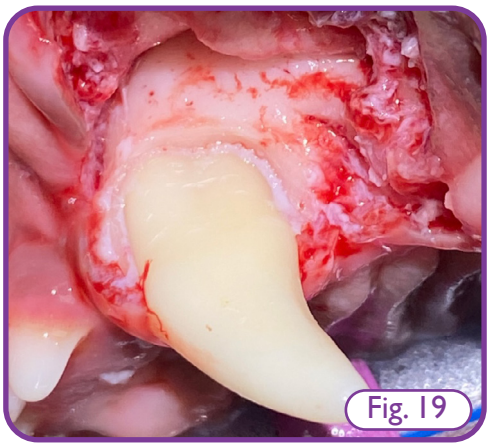


Fig. 19

The following images illustrate the extent of the mucoperiosteal flap (yellow dotted line) and the alveloectomy (shaded area), relative to the tooth root (solid outline) for the following teeth:

Fig. 20a: Maxillary canine tooth - canine patient.
Fig. 20b: Maxillary canine tooth - feline patient.
Fig. 20c: Mandibular canine tooth.
Fig. 20d: Molar tooth - feline patient.
Fig 20e: Premolar teeth 4 and 3 - canine patient.

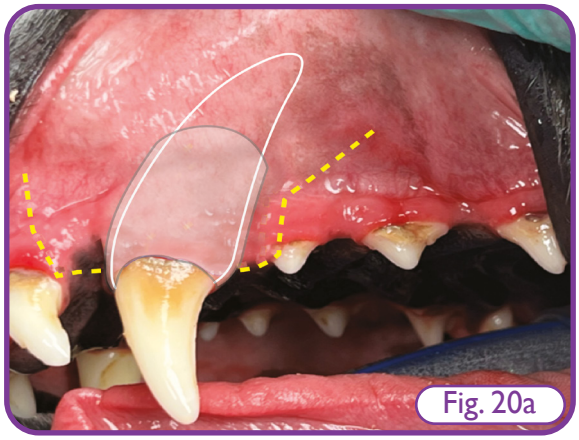


Fig. 20a

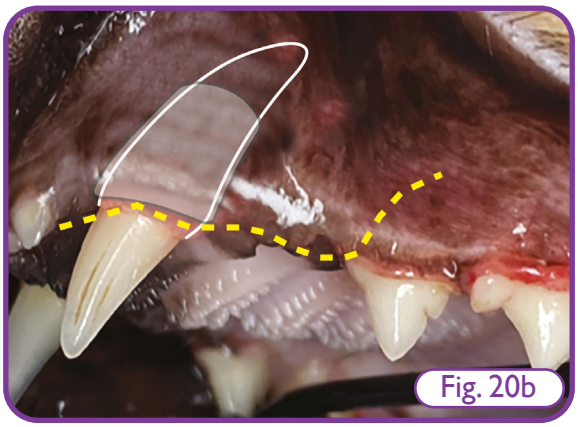


Fig. 20b

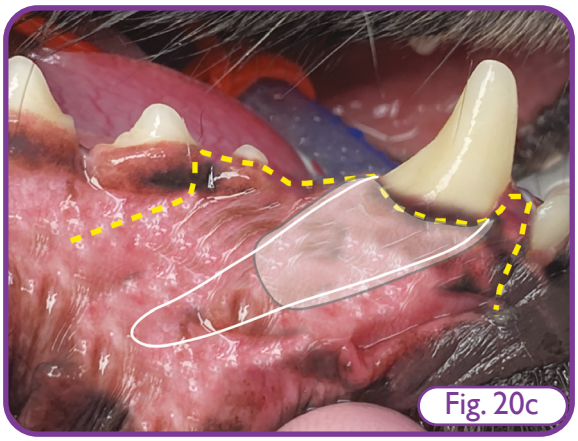


Fig. 20c

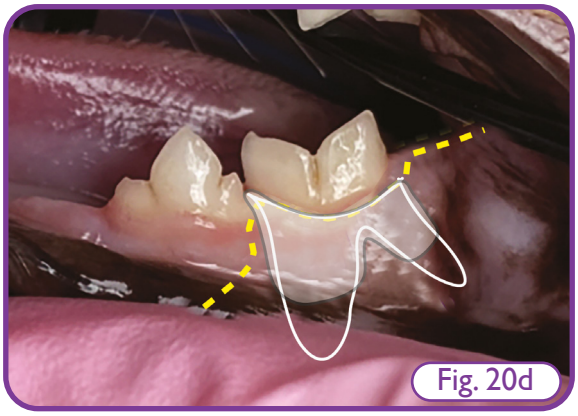


Fig. 20d

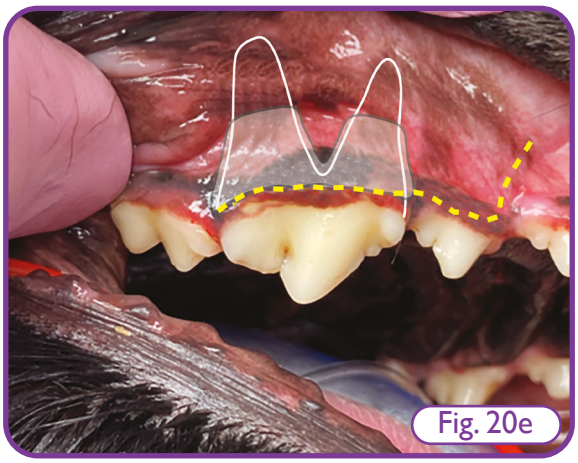


Fig. 20e

Click here to watch a short video of an alveolectomy being performed.

Alveoplasty

Following tooth removal, the alveolar margin should be contoured and beveled to prevent any sharp bone from traumatising the overlying Mc-P flap. Alveoplasty should also smooth out the contours of bone, to minimise stress concentration under post-operative loading whilst preserving as much healthy bone as possible.

Alveoplasty can be performed with a large round tungsten carbide bur or round diamond bur. Digital palpation of the extraction site should be performed at this time to assess the contours of the site and adjustment of the alveoplasty made if needed. Alveoplasty is commonly required on the palatal/ lingual alveolar margin, and the gingiva should be elevated to facilitate this. This is especially important following extraction of the maxillary canine tooth. Elevation of the lingual/ palatal mucosa will also facilitate closure.

Click here to watch a short video of an alveoplasty being performed.

Wound closure

Halsted's principles apply to oral surgery as they do to general surgery.

- Gentle tissue handling.
- Meticulous haemostasis.
- Preservation of blood supply.
- (Strict asepsis).
- Minimum tension.
- Accurate apposition.
- Obliteration of dead space.

Prior to wound closure the alveolus should be debrided of granulation tissue and diseased bone, followed by gentle irrigation. Irrigation can be with distilled water from the three way tap without the simultaneous air.

Wound closure aids with haemostasis through means of tamponade, and reduces the risk of loss of the blood clot from the alveolus and post operative haemorrhage. Loss of clot in humans is associated with formation of the exceedingly painful condition of dry socket. This is likely under-reported in veterinary patients.

Wound closure should be appositional and without tension. The tissues should be laid across the defect and not restrict when released. Use simple interrupted or cruciate mattress sutures or, for larger wounds, simple continuous patterns are all appropriate.

Sutures should be 3mm from the wound edge, 3mm apart and the tails of the suture cut to 3mm. (Fig. 21). Monofilament absorbable suture is preferred to minimise wicking. The author's preference is poliglecaprone 25, 4/0 with 19mm FS-2 reverse cutting needle for dogs greater than 10kg and 5/0 with 13mm P3 reverse cutting needle for dogs less than 10kgs, and cats.

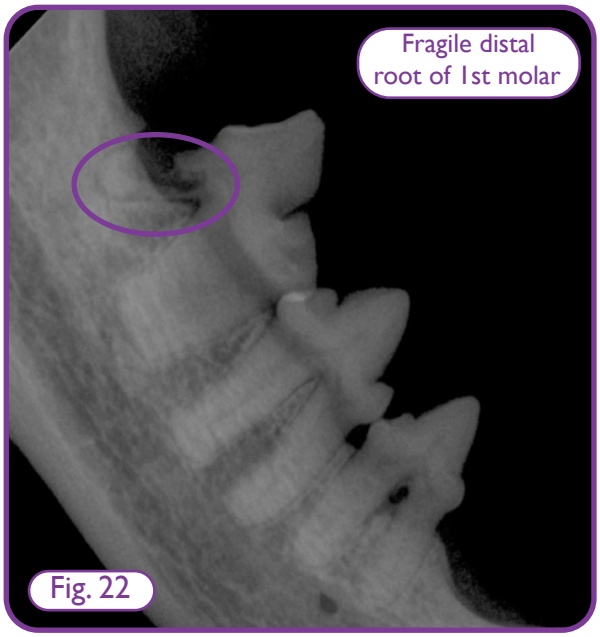
Achieving tension free closure is critical to successful wound healing in oral tissues.

Intra-operative challenges

The quality of a surgeon is not expressed when all is going well but in dealing with the inevitable intra-operative challenges which happen to us all. Understanding of the potential difficulties allows the surgeon to take steps to avoid, mitigate their effects or deal with the consequences in a calm and pre-planned manner.

Root fracture

Iatrogenic root fracture is the most common form of intra-operative challenge routinely faced by the oral surgeon. Pre-operative radiographs may provide the surgeon with predictive information indicating a higher risk of root fracture due to existing pathology. (Fig. 22).



In the event of root fracture:

- Radiograph the root fragment.
  - Correlation of the surface topology of the alveolar bone can guide where to insert instruments or perform targeted alveolectomy.

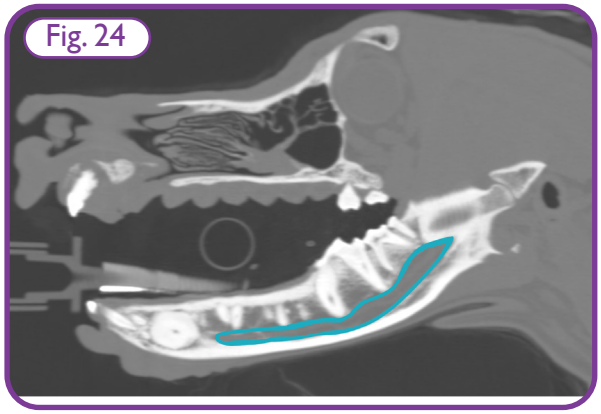
If performing a simple extraction convert to surgical extraction.

  - Visualisation is critical to successful extraction.
  - Use magnification (loupes) with targeted light, suction and intermittent irrigation retraction and have an assistant if at all possible.
- If performing a surgical extraction, increase the exposure of the flap and expand the alveolectomy.
  - The tooth root can usually be differentiated from bone by colour (white bone and ivory tooth) and the presence of the root canal in its centre.
  - Smoothing the interface between the bone and root can aid with identification using a diamond bur.
- Alveolectomy may be "intra-boney", to minimise loss of alveolar bone height.
  - Using fine long-shanked surgical or root tip burs will be of significant benefit.
  - Follow the periodontal ligament down the root fragment.
    - This creates space for insertion of a fine instrument, and increases mechanical advantage.
    - Avoid intrusive pressure on the root, force exerts onto the periodontal ligament, as root tip displacement may occur.

When performing extended alveolectomy, care should be taken not to traumatise adjacent neuro-vascular structures.

- Maxillary 3rd premolar; close to the infraorbital foramen especially brachycephalic breeds.
- Mesio-palatal root of the maxillary 4th premolar in brachycephalic breeds. (Fig. 23).
  - Avoid bone removal on the inter-radicular surface and focus on mesial, palatal and distal surfaces

- Mandibular 4th premolar and 1st molar teeth especially small and toy breeds.
  - The mandibular canal (Fig. 24) may course on the lingual or buccal (most common) surface of the roots of the 4th premolar and 1st molar teeth if the mandible has a relatively short height and the root length proportionally long.
  - Bone removal should be performed on the mesial and distal surface and avoid the buccal and lingual surfaces where penetration of the mandibular canal could occur.



Root tip intrusion can occur into the mandibular canal or the maxillary recess/ nasal cavity. The presence of apical disease and an extensive alveolectomy will increase the risk of intrusion. Avoidance is easier than subsequent removal and good technique without apical pressure is appropriate. In the event of intrusion, it may be appropriate not to attempt removal if the fragment is not visible; further iatrogenic damage may occur, such as significant haemorrhage. Small fragments may be well tolerated, if there is no endodontic or apical periodontal infection, and radiographic re-evaluation, after 3 to 6 months, and owner monitoring for evidence of neuralgia may all be that is needed. Removal of intruded fragments may be necessary and if so, advanced imaging may be of significant benefit in pinpointing the three-dimensional position of the fragment.

Loss of control of elevating instruments has been reported to result in neuromuscular trauma, penetration into the retrobulbar space resulting in cellulitis, globe penetration resulting in panopthalmitis and need for enucleation and even brain penetration.

- Care in high-risk areas, especially extraction of the maxillary 2nd molar in dogs.
- Minimise apically directed forces especially if apical disease is present.
- Hold elevating instruments in a modified palm grip with index finger close to the tip to prevent deep penetration if slipping occurs.
- Sharp instruments cut more efficiently and reduce the force required.
- Appropriate angulation of tip of instrument is toward the apex for dental elevators.

The use of high-speed rotatory burs to perform sectioning of teeth or alveolectomy causes a vortex effect, that will inadvertently pull soft tissues towards the rotating instrument. Significant trauma to the carefully elevated soft tissues is likely to result. This is especially common when dividing multi-rooted teeth, such as the mandibular 4th premolar and 1st and 2nd molar teeth with injury to the para-lingual tissues. Partially sectioning the tooth and then controlled fracture is possible, or use of a sacrificial retractor such as a plastic mixing spatula will help to avoid this.

Haemorrhage

The oral cavity is exceedingly well supplied by blood which is beneficial for healing but some surgical haemorrhage will be expected. Simple pressure application or ligation of a vessel where possible is most commonly sufficient to control. Wound closure will aid haemostasis through tamponade. Haemostatic agents such as Vetigel (available through Vi - Fig. 25) and electrocautery can be useful if more extensive haemorrhage is evident. Breeds at risk of clotting deficiencies, such as Doberman Pinschers, should be assessed for clotting performance prior to surgery. Use of tranexamic acid preoperatively for sight hound breeds is advised.

Fig. 25

Jaw fracture

Iatrogenic jaw fracture is one of the greatest concerns of both clinician and owner during extraction and should be discussed as part of the pre-operative consultation. The risk of fracture should be considered low, but extraction of the mandibular canine, 4th premolar and 1st molar are associated with a greater risk of fracture. This risk will be significantly increased in patients with relatively delicate mandibles and severe bone loss, such as seen in toy breeds with severe periodontitis. Using the non-dominant hand to stabilise the mandible allows the operator to appreciate mandibular torsion and alert them when reaching forces that may lead to fracture. Surgical extractions are likely to be more controlled and lower forces needed to extract the tooth. Avoid extreme buccal tipping if elevating the mandibular canine tooth from the mesio-lingual surface.

Post-operative complications

Post operative complications can be subdivided into acute and chronic but there is likely to be some overlap between these groups.

Acute
Pain
Haemorrhage
Wound dehiscence
Dry Socket
Cellulitis
Chronic
Abscessation
Sequestration
Osteonecrosis

Pain

Pain should be an expected consequence of any invasive surgical procedure, but inappropriate levels of pain are uncommon following oral surgery. Post-operative discomfort is expected to be more significant where extensive bone removal has been performed. Use of appropriate intra-operative pain relief, anti-inflammatories and regional anaesthetic techniques will markedly reduce postoperative pain. Long standing oral pathologies may have resulted in neuropathic wind up with the consequence of increased difficulty in managing intra-operative pain response and greater apparent levels of post-operative discomfort than would be expected. Use of medications such as ketamine and off-licence gabapentin and amantadine pre- and post-operatively can be highly beneficial.

Haemorrhage

Appropriate intra-operative control of haemorrhage and closure of oral wounds should minimise the potential for post-operative haemorrhage, haematoma may develop prior to tamponade although this is undesirable due to the increased risk of wound dehiscence and infection. Significant volumes of haemorrhage immediately post-operatively should be investigated under sedation or anaesthesia and is likely to be associated with trauma. The author advocates the use of intravenous tranexamic acid (TA), 10mg/kg, for sighthounds immediately prior to oral surgical procedures due to their risk of inappropriate fibrinolysis. Continued post-operative oral TA may be appropriate if excess haemorrhage was noted intra-operatively or there is a historic risk in individual patients.

Dry socket

Dry socket is alveolitis/ osteitis following loss or lack of formation of a blood clot following extraction. It is reported in up to 5% of routine extraction in humans with particular risk associated with impacted wisdom teeth. There is likely to be under-reporting/ identification of this condition in companion animals. It is associated with unexpected pain developing 3 to 5 days following extractions.

Wound dehiscence

Wound dehiscence may be the most common postoperative complications and risk of its development is likely to be both associated with surgical operator and patient factors. Licking at sutures, inappropriate play and trauma, access to hard foods and toys may all contribute to dehiscence. The presence of tension across a wound, lack of bone support under the sutures and damage or lack of vascular supply to oral mucosa at the healing edges are the most common cause of wound dehiscence. Operator factors can be controlled whereas patient factors are less easy to control; our focus should be on controlling what we can. Dehiscence rarely requires surgical re-intervention and the author would advise waiting for tissues to be quiescent before considering intervention; this would often require 3 to 4 weeks and secondary intention healing is commonly complete by this time.

Wound dehiscence of maxillary extractions, especially the maxillary canine teeth, may result in development of oro-nasal fistulae. (Fig. 26). These communications have a continuous mucosal lining connecting the oral and nasal mucosa and as a result will not heal without surgical intervention.

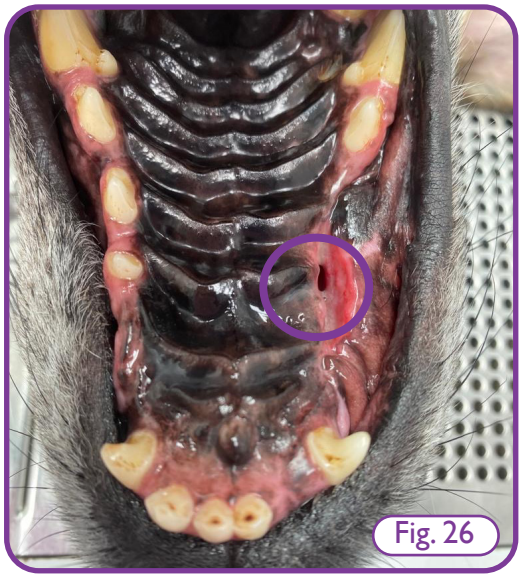


Fig. 26

Abscessation

Post-operative abscessation is most commonly associated with the inappropriate retention of root tissue or the formation of a bone sequestrum. Routine post-extraction radiographs are likely to be effective in mitigating this risk. Fluctuant, antibiotic-responsive swelling should be explored radiographically, and in some cases with advanced imaging. Healing of overlying oral mucosa is not a reliable marker for the presence of a root fragment.

Osteonecrosis

Osteonecrosis (ON) (Fig. 27) is an uncommon development but is commonly associated with recent dental extractions.

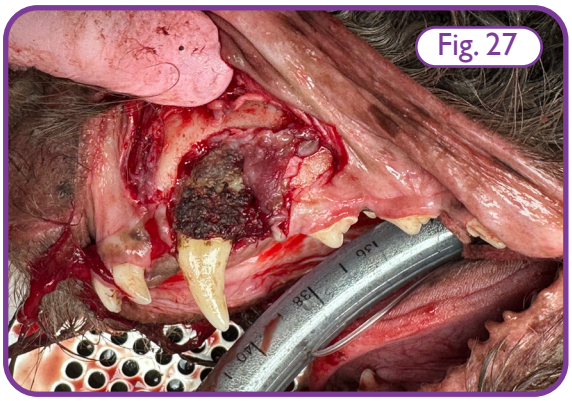


Fig. 27

ON is over-represented in certain breeds, such as Scottish Terriers, and the author is suspicious that it may be linked to the presence of canine chronic ulcerative stomatitis in dogs. Patients suffering from ON commonly present with general malaise and profound halitosis. Oral examination often reveals full thickness ulceration overlying grey or green non-vital bone. Treatment requires debridement/ removal of all necrotic bone. Accurate assessment of the extent of the necrosis is appropriate as segmental maxillectomy or mandibulectomy may be indicated.

Rational use of antibiotics

Antibiotics are rarely indicated in oral surgery due to the majority of pathologies being associated with plaque. The nature of the biofilm confers significant protection from antibiotic actions, rendering normal pharmacologic concentrations of antibiotics ineffective. Where the presence of planktonic bacteria have resulted in cellulitis, antibiotics are indicated.

The oral microbiome is complex, many bacterial species present are not able to be cultured by routine techniques and those that can are often expected commensals. Where purulent gingival or periodontal infections are present or osteomyelitis (Fig. 28) is suspected, tissue samples should be collected for maceration and culture to guide extended antibiotic selection.


Fig. 28

Antibiotics are **not** indicated for:

- Routine periodontal therapy.
- Tooth resorption.
- Wound dehiscence unless active infection is evident.
- Periodontal disease.
- Tooth root abscess unless cellulitis is present.
- Feline gingivitis stomatitis complex or chronic canine ulcerative stomatitis.

Oral treatments, tooth brushing and even chewing will result in bacteraemia, in the presence of periodontal disease, which is short lived and obviously commonly encountered by the patient's immune system. Peri-operative antibiotics will shorten the duration of the bacteraemia but not prevent it.

Peri-operative antibiotics **are** indicated for:

- Open mandibular fractures
- Patients with systemic immunosuppression due to comorbidity or medication.
- Patients with sub-aortic or aortic stenosis
- Patients with pacemaker leads implanted into the heart.
- Patients that have previously suffered from bacterial endocarditis.

When indicated, peri-operative antibiotics are best administered in high doses intravenously immediately prior to commencing the surgical procedure. Commonly preferred antibiotics effective against the normal oral microbiome are; cefuroxime, 22mg/kg, or amoxicillin/clavulanate, 20-25mg/kg, repeated every 90 minutes until the end of surgery.

With sincere thanks to **Andrew Perry** BVSc Dip EVDC MRCVS EBVS European Veterinary Specialist in Dentistry for his time and invaluable assistance with the creation of this Surgery Guide,

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