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# Disorders of the Oral Cavity

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# Contents

# Surgical Treatment of Facial Abscesses and Facial Surgery in Pet Rabbits

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**KEYWORDS**

• Abscess • Osteomyelitis • Empyema • Retrobulbar • Marsupialization
• Mandibulectomy

**KEY POINTS**

- Understanding of dental and anatomic features of the jaws and the skull is critical for interpretation of diagnostic imaging and for the surgical treatment of odontogenic facial abscesses and their complications.
- Thorough diagnostic imaging (including radiography, oral endoscopy, computed tomography, and magnetic resonance) is of paramount importance for diagnostic accuracy, prognosis, and for planning surgical treatment.
- Medical therapy alone is unrewarding, but important as an adjunct to the surgical therapy.
- Aggressive surgical treatment is necessary to remove the abscess capsule, extract the diseased teeth involved, and address the focal osteomyelitis.
- Further complications, such as retromasseteric and retrobulbar abscesses, extensive osteomyelitis of the mandible, and empyemas of the skull, should be addressed with specific surgical techniques and approaches.

## INTRODUCTION

The most common complications of acquired dental disease in pet rabbits are periapical infections, osteomyelitis of the jaw, and facial abscesses.[1–4] They comprise a considerable portion of acquired and progressive dental disease syndrome (ADD). Facial abscesses appear as large masses, usually located at the ventrolateral aspect of the mandible or the lateral aspect of the maxilla.[1,2,4] Some rabbits may have an obvious unilateral exophthalmos.[4,5]

The abscess does not represent the primary disease, therefore thorough diagnosis (including standard or advanced diagnostic imaging) should be pursued to make a

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proper prognosis, identify surgical candidates, and plan the most effective treatment using the most appropriate surgical approach.[5] Medical therapy alone is unrewarding, although it is an important adjunct to the dental and surgical treatment, which is usually a combined intraoral and extraoral approach. Numerous variations of surgical techniques have been reported, but the extraoral treatment is intended to address all 3 pathologic components: to remove the entire abscess including the capsule, extract the tooth fragments involved, and debride the osteomyelitic bone.[2]

Further complications, such as retromasseteric and retrobulbar abscesses, extensive osteomyelitis of the mandible, and empyemas of the skull, may require more invasive and challenging surgical techniques.[5]

## ANATOMY AND SURGICAL ANATOMY

Detailed knowledge of the normal, topographic, and surgical anatomy of the teeth and skull with a focus on the mandible and maxilla is important for understanding classification of the abscesses and empyemas and their pathophysiology. It is also critical for interpretation of diagnostic imaging techniques, and to perform surgical techniques.

### *Mandible*

The topographic anatomy outlines 3 portions of the rabbit mandible.[5,6]

1. The incisive part, in which the 2 mandibles are joined rostrally by the mandibular symphysis. This portion includes the reserve crown and apex of the incisor teeth.
2. The body of the mandible, which includes the reserve crowns and apices of the premolar and molar teeth.
3. The masseteric fossa and the branch of the mandible, with the condylar process. The area of the masseteric fossa is very thin, because it accommodates the masticatory muscles in a double groove both laterally and medially. The masseter muscle, positioned laterally, is composed of 2 main layers (the superficial and the deep part) and is of particular surgical interest.

### *Maxilla and Skull*

The alveolar bulla is a unique bony structure specific to rabbits, which includes the reserve crowns and apices of the 4 distal (caudal) maxillary cheek teeth (the third premolar, and the 3 molar teeth, CT3–CT6).[1,5–7] Reserve crowns of the first 2 premolars (CT1 and CT2) are located more cranially and outside the alveolar bulla. The dome of the alveolar bulla is adjacent to the cranioventral aspect of the orbital fossa, and caudolaterally adjacent to the lacrimal bone.

The lacrimal bone separates the cranial aspect of the alveolar bulla from the nasolacrimal duct, and craniomedially from the maxillary recess.[8]

Rabbits have 3 main lacrimal glands (lacrimal gland proper, accessory lacrimal gland, and the gland of the nictitating membrane) of which 2 are divided into multiple lobes.[6,7,9,10] The lacrimal gland proper is located in the caudodorsal area of the orbit. The accessory lacrimal gland is much larger and divided in 3 lobes: the orbital, the retro-orbital, and the infraorbital. The gland associated with the nictitating membrane is commonly referred to as the harderian gland and is divided into the superficial gland and the deep gland.

The nasolacrimal duct runs from the orbital fossa to the nasal cavity. It curves medially, passes through the infratrochlear incisure and the foramen of the lacrimal bone, and enters the bony nasolacrimal canal medial to the maxillary bone, being adjacent to the maxillary recess.[8,11,12]

The conchae, also called nasal turbinates, are highly convoluted cartilaginous membranes covered by mucosa filling the nasal cavities. They outline empty spaces (meatuses) and blind cavities (recesses).[8] The paranasal cavities of rabbits are represented by the paired dorsal conchal, the sphenoidal, and the large double-chambered maxillary recesses.[8,13]

The tympanic bulla is well developed in rabbits. Unlike the alveolar bulla, it is a normally cavitary bone located caudally and laterally at the base of the skull.[6,14] The tympanic bulla communicates laterally with the ear canal entering the alveolar bulla through the external acoustic meatus (but separated by the tympanic membrane), and medially with the pharynx through the eustachian tubes.

## CLINICAL PRESENTATION

Facial abscesses appear as large masses, usually located at the ventrolateral aspect of the mandible or the lateral aspect of the maxilla (**Fig. 1**).[1,2,4] Some rabbits show an obvious unilateral exophthalmos.[4,5] Abscesses are typically firm, cool, and nonpainful on palpation.[4] Early small masses are usually missed by the owners because of their location and the presence of fur, especially in long-haired rabbits. However, they may increase to considerable size. Occasionally, part of the overlying skin is necrotic, and a fistula or rupture may occur.

## PATHOPHYSIOLOGY AND CLINICAL CONSIDERATIONS

Periapical infections represent the most common complications of acquired dental disease in pet rabbits.[1–4] They comprise a considerable portion of the ADD. Because of the specific anatomy of rabbit teeth, and the relationship between the reserve crown and the adjacent alveolar bones, periapical infections often quickly involve surrounding bone and adjacent soft tissues, producing abscesses and osteomyelitis.[2]

Facial abscesses can be single or multiple, or multilobed within a single entity. They are typically surrounded by a thick and well-developed capsule, and contain white, creamy pus.[1]

Part of the pathophysiology and clinical implications of periapical infections and abscessations in rabbits are not yet completely understood, especially compared with the same disease in non-herbivorous species. Rabbits are a prey species, therefore naturally prone to hide the symptoms of a disease, which may explain why clinicians frequently see advanced stages of acquired dental disease already complicated by periapical infection, abscessation of soft tissues, and osteomyelitis before early symptoms are detected by the owners.[2] However, this is not sufficient to explain the various clinical conditions displayed by different individuals.

The pain component seems to be extremely variable among patients, and it is not clear which component of this complex disease produces the most pain. Patients without concurrent severe intraoral dental disease and related complications, such as coronal spikes creating lesions to the tongue and other soft tissues, do not seem to be painful even at an advanced stage.[2] Those patients lacking intraoral lesions and evident malocclusion are usually able to eat normally. Pain can be elicited on palpation at the bony infection site, but is usually absent on palpation of the mass. With regard to further complications, such as extensive osteomyelitis or exophthalmos, the range of symptoms is even broader. Most patients with end-stage dental disease complicated by chronic, extensive osteomyelitis produce very large and multiple facial abscesses that can rapidly progress to weight loss and emaciation if aggressive treatment is not pursued. However, other animals with single or multiple foci of osteomyelitis and/or empyemas may live for several years in fair overall health.

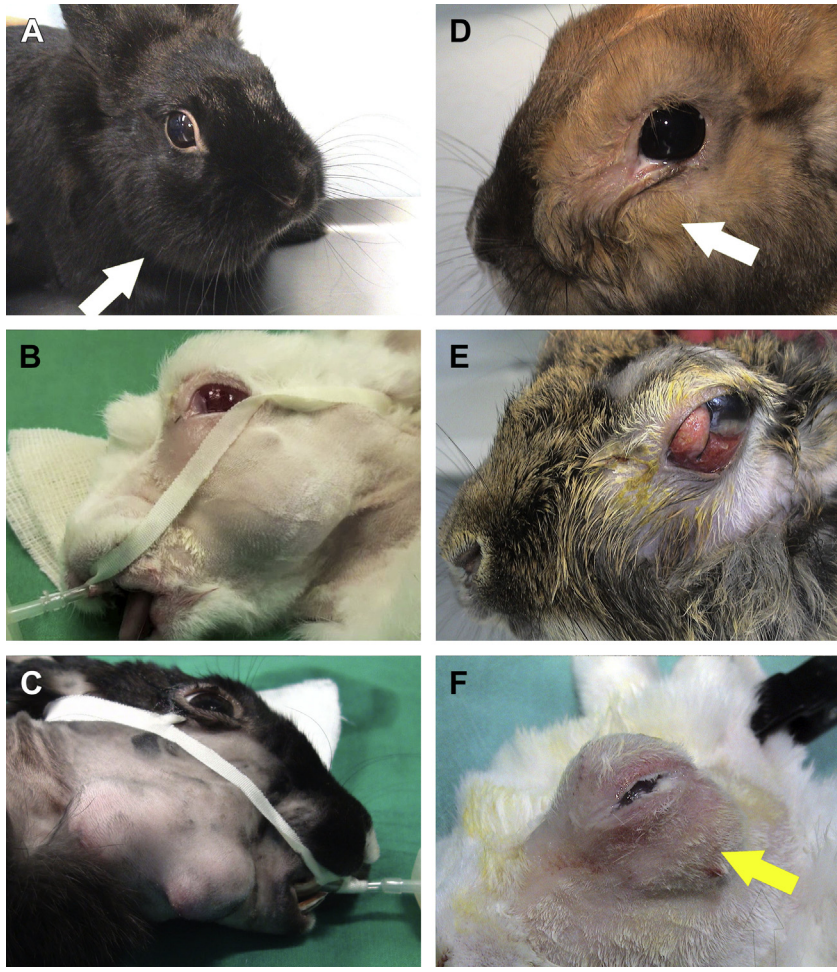


**Fig. 1.** Clinical presentation of odontogenic facial abscesses. (*A*) Mandibular swelling following periapical infection of the right CT1 (*arrow*). These masses are typically not as evident before shaving. Palpation is critical to evaluate size and position. (*B*) Swelling of the zygomatic area caused by periapical infection of the maxillary CT1 (*arrow*). Epiphora is present. (*C*) Retromasseteric abscess following periapical infection of mandibular CT4. (*D*) Exophthalmos caused by a retrobulbar abscess. Ocular complications such as conjunctivitis, keratitis, and prolapse of the third eyelid are present. (*E*) Multiple mandibular abscesses in a rabbit with extensive osteomyelitis of the mandible following advanced dental disease. (*F*) Parabulbar abscess affecting the accessory lacrimal gland (*arrow*). Exophthalmos is present, but the swelling is more lateral to the orbit compared with the deep retrobulbar abscesses. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

Three more aspects having important clinical and surgical impact are related to hyperthermia, local pathologic features, and anatomic features.[2] Periapical infections and osteomyelitis represent a true septic inflammatory process; however, they do not elicit hyperthermia. Also, the local infection tends to be encapsulated (while it progressively destroys the surrounding bone), and this likely plays a critical role in the antimicrobial treatment alone being ineffective.

Advanced ADD (coupled with specific anatomic features of the rabbit skull) may also elicit the formation of empyemas.[5] An empyema is defined as a collection or gathering of pus within a naturally existing anatomic cavity. It is different from an abscess because the latter is a collection of pus in a newly formed cavity surrounded by a capsule. The rabbit skull has at least 3 preformed anatomic cavities that may be involved following ADD and bacterial complications: the nasal cavity with its meatuses, the maxillary recess, and the tympanic bulla.[5,6] A fourth bony cavity of the skull can also be affected by empyema: the alveolar bulla. Although this preformed cavity is not normally empty, because it includes the reserve crowns of maxillary CT3 to CT6, in the case of dental disease or tooth extraction, it can be enlarged and/or partially empty, acting as a pathologic cavity (without a capsule) and therefore be affected by an empyema. Empyemas of the skull may or may not be concurrent with odontogenic abscesses, in cases of advanced ADD. Similarly, 1 or more empyemas can be subsequently or even concurrently present in the same patient, leading to the rabbit skull empyema syndrome.[5]

The anatomic features and the small size of the skull and teeth of rabbits make the dental and/or the surgical treatment difficult in general.[2] In select advanced or complicated cases, it can be very challenging. The presence of the orbit and the eye globe makes surgical access especially difficult when treating certain maxillary abscesses.

## PROGNOSIS

The many complications leading to facial abscesses, empyemas, and possible further involvement of facial structures make discussion of prognosis in general virtually limitless and impossible. Prognosis should therefore be tailored to the specific patient and case.

The first critical element for a proper prognosis is diagnostic accuracy.[15] The diagnosis must be correct and as detailed as possible, specifically with regard to dental and bony involvement. Therefore, diagnostic imaging, both standard (radiography, oral endoscopy) and advanced (computed tomography, magnetic resonance) is of paramount importance.[6]

Several practical, even nonmedical, factors should be considered when formulating the prognosis. They include the management during the postoperative period, the owner's understanding and compliance (in particular with regard to advanced and chronic disease), and cost.[4]

Because of enhanced diagnostic imaging, improved surgical techniques, and overall treatment advances, prognosis is more favorable even for complex cases, than it was just a few years ago. Rabbits can show surprising improvements after facial surgery, and even chronic cases can be managed for years with a good quality of life.

## MEDICAL TREATMENT VERSUS SURGICAL TREATMENT: THE ROLE OF OSTEOMYELITIS

Because periapical infection, osteomyelitis, and abscesses are bacterial infections, antimicrobial therapy is indicated.[2,4] The best therapeutic choices come from culture/sensitivity, keeping in mind that the core of the abscess is usually sterile and that a portion of the capsule should be submitted for sensitivity; that anaerobic organisms are frequently involved, therefore different culture techniques should be pursued; and taking into consideration the potential toxicity of many common antibiotics in rabbits.[1,2,4,16]

Bacteria isolated from complications of ADD in rabbits have been extensively published, as well as their sensitivity to antibiotics. According to one study, both anaerobic gram-negative[17] and aerobic gram-positive pathogenic bacteria have been

identified,[17] including *Fusobacterium nucleatum*,[17,18] *Prevotella* spp, *Pseudomonas* spp, *Streptococcus* spp, and *Actinomyces israelii*.[17] Common rabbit pathogens such as *Pasteurella multocida* were not isolated.[17] Sensitivity testing indicated that 100% of pathogens were susceptible to clindamycin and chloramphenicol, 96% to penicillin, 86% to tetracycline, and 54% to metronidazole and ciprofloxacin.[17]

A more recent, large-scale, retrospective study performed on 81 rabbits[19] reported that the most common bacterial aerobic isolates were *Pseudomonas* spp, *Pasteurella* spp, *Streptococcus* spp, and *Staphylococcus* spp; and the most common bacterial anaerobic isolates were *Fusobacterium* spp, *Peptostreptococcus* spp, and *Bacteroides* spp. Antimicrobial susceptibilities varied depending on the bacterial isolate, with *Pseudomonas* spp most susceptible to amikacin and gentamicin; *Pasteurella* spp susceptible to trimethoprim-sulfamethoxazole, aminopenicillins, amikacin, and gentamicin; *Streptococcus* spp susceptible to most antibiotics evaluated; and *Staphylococcus* spp susceptible to amikacin, gentamicin, chloramphenicol, trimethoprim-sulfamethoxazole, and aminopenicillins.

Nevertheless, with the exception of some anecdotal reports, no clinical trials have shown that medical therapy alone is effective. This finding is easy to understand if the 3 distinguishing traits of periapical infections and abscesses of rabbits are considered: the presence of a capsule, the osteomyelitis, and the diseased tissue (soft, dental, and bony) acting as a sequestrum.[2,4] Treatment of all 3 pathologic conditions must be pursued and addressed in order to obtain long-term therapeutic success and prevent frequent reoccurrence. The combined dental and surgical treatment is designed to remove the entire capsule and the affected tooth/teeth, and to thoroughly debride the osteomyelitic bone.[1,2,4,20,21] This outcome ultimately facilitates the efficacy of antibiotic therapy.

In addition to antibiotic therapy, the key points of medical treatment should include supportive (fluids and nutrition with assisted feeding formulas for herbivores) and analgesic therapy when indicated.[1,4] Both should be tailored for every patient, because many of them have a normal appetite even in presence of an abscess, and may show little to no evidence of pain. Medical and supportive treatment is critical for debilitated patients before surgical intervention, and in general when gastrointestinal complications are present following reduced food intake. Rabbits typically resume eating well soon after a dental or extraoral surgical treatment, and show noticeable improvement even after an aggressive surgery, compared with the clinical conditions before the surgical treatment of the abscess.

## PRINCIPLES OF SURGICAL TREATMENT

The surgical treatment of facial abscesses has been extensively reported in the literature. The goal of most surgical procedures, except wound packing, is to remove the entire abscess including the capsule, extract the tooth fragments involved, and debride the osteomyelitic bone.[1,2,4,20,21] Various surgical options have been reported beyond the simple (and usually ineffective) incision of the abscess followed by flushing of the purulent content. Minimal surgical debridement, without removing the capsule, has been reported as an effective treatment option in rabbits with dental abscesses.[22] This technique involves the incision of the abscess, minimal debridement and cleaning of the abscess cavity, and packing the cavity with strips of sterile gauze 3 to 5 mm in diameter and impregnated with antibiotics, most commonly ampicillin or clindamycin. The gauze is changed weekly until granulation tissue fills the cavity and the abscess is resolved. Rabbits are concurrently treated with systemic antibiotics such as trimethoprim and metronidazole, enrofloxacin and metronidazole, or azithromycin.

Placement of antibiotic-impregnated polymethyl methacrylate (AIPMMA) beads may be necessary in conjunction with gauze packing in cases with early osteomyelitis and bone defects. This procedure may be an option in rabbits with minimal osteomyelitis. However, efficacy in rabbits with extensive bony involvement is not known.

Excision of the abscess may be followed by either primary closure after packing of the surgical site with AIPMMA beads,[1,3,23–27] or marsupialization.[1,2,21] Additional local treatment of the open site has been reported in many different ways, including packing with calcium hydroxide,[1,28] honey,[3,29,30] sugar[31] solution, Intrasite Gel (Smith & Nephew, London, United Kingdom),[3] or bioactive ceramics.[20]

Marsupialization of the soft tissues around the area of the affected bone has been the author's treatment of choice for more than 15 years because this procedure is associated with a high percentage of successful outcomes and long-term postoperative follow-up, particularly in cases of deep or severe osteomyelitis, which are common. Ideally, the surgical technique should allow postoperative flushing and debridement of the surgical site, application of antiseptics or other products to promote healing, and constant direct monitoring of healing. This method is based on the same basic principles of orthopedics as when a grade III open fracture and an osteomyelitic site are present.[2] The fracture repair is usually performed with an external fixation technique and the infected site left partially exposed. Marsupialization of the surgical site allows these same surgical principles in cases of osteomyelitis of the skull.

Possible hospitalization for management of the wound during the first days, a longer postoperative period, frequent rechecks, temporarily unattractive cosmetic appearance, and significant owner commitment should be discussed with the owner before surgery.[2,4]

## ABSCESSES AND OSTEOMYELITIS OF THE MANDIBLE

### *Periapical Infection of Mandibular Premolar Teeth and Focal Osteomyelitis of the Body of the Mandible*

Following induction of general anesthesia, the patient is maintained via orotracheal intubation and positioned in dorsal or lateral recumbency, depending on the location of the abscess.[1,2,5,21] Adjunct local anesthesia can be achieved by performing local nerve blocks of the mental and the inferior alveolar nerves.[32,33] The surgical site is shaved, aseptically prepared, and draped. Transparent or semitransparent drapes are preferred because they facilitate visualization of the orientation of the head. A skin incision is made over the mass, preserving the capsule and taking care not to enter the underlying abscess. The subcutaneous tissue and muscle layers are bluntly dissected to expose the capsule of the abscess. The junction between the capsule and the underlying cortical bone is dissected with a scalpel blade or sharp scissors. The wall of the abscess is removed, including thin bone when cortical reaction is present. A small portion of the capsule is submitted for culture and sensitivity testing, because the purulent material inside is often sterile. The purulent exudate is removed using cotton-tipped applicators, and the bone cavity is thoroughly flushed using saline or 0.1% chlorhexidine solution. The infected or necrotic cortical bone is debrided using a bone curette. If present, fragments of the diseased teeth are meticulously worked with small dental elevators or contoured needles, to free the attachment to the bone, and extracted. In some cases, the tooth fragment is ankylotic to a small piece of necrotic alveolar bone. The bone cavity is again flushed as described earlier. Marsupialization of the soft tissues around the surgical site is performed using 3-0 or smaller nonabsorbable suture material (**Fig. 2**).

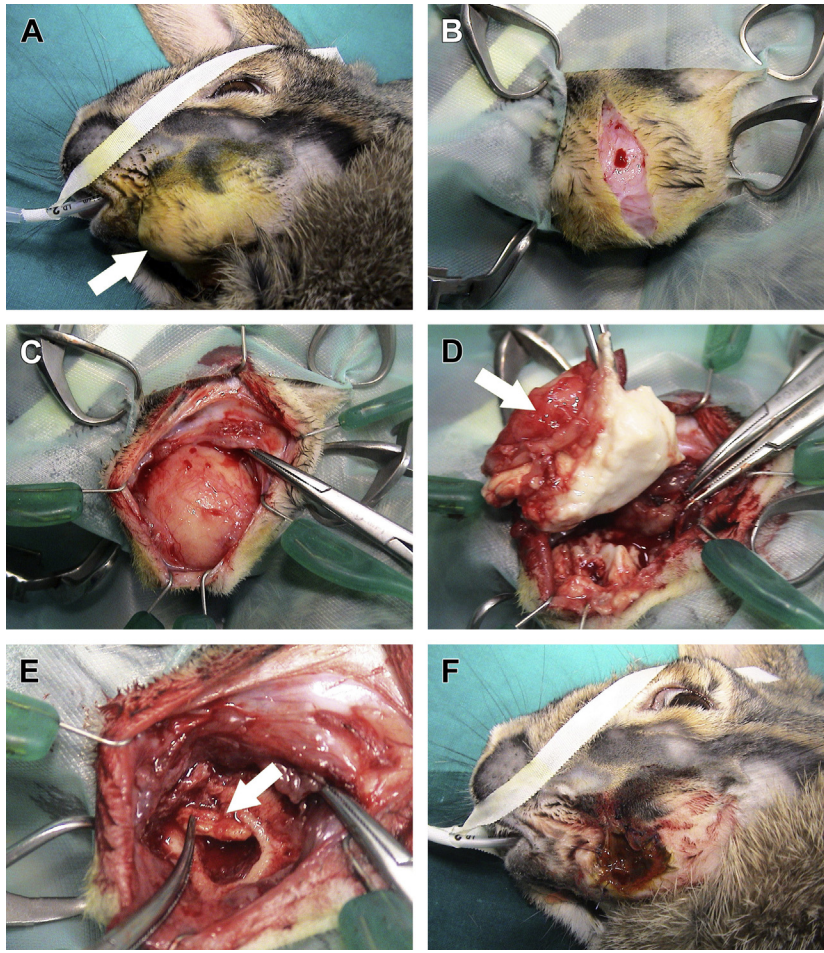


**Fig. 2.** Surgical treatment of a mandibular abscess with focal osteomyelitis of the body of the mandible. (*A*) The anesthetized patient is placed in lateral recumbency. (*B*) The area is surgically prepared with a plastic, semitransparent, nonadhesive drape. A skin incision is performed over the abscess, preserving the capsule. (*C*) The subcutaneous tissue and muscle layers are bluntly dissected and retracted to expose the capsule of the abscess. (*D*) The abscess is dissected free from the underlying bone. The thick purulent exudate is removed and a small portion of the capsule (*arrow*) is submitted for culture and sensitivity testing. (*E*) The bone cavity is thoroughly flushed with saline and debrided using a bone curette. The diseased tooth is worked with small dental elevators or contoured needles, and extracted (*arrow*). (*F*) Marsupialization and cosmetic appearance at the end of the surgical procedure. The surgical site has been filled with iodopovidone cream. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

### *Periapical Infection of Mandibular Incisor Teeth and Osteomyelitis of the Incisive Portion of the Mandible*

The involvement of the incisive portion of the mandible is less common because both inspection and extraction of incisor teeth are easier than for premolar teeth.[1,5] The surgical technique is similar to the previous description; however, the approach is slightly

more cranial. Because of anatomic proximity, periapical infection of a mandibular incisor tooth may be associated with periapical infection of the ipsilateral premolar, making the approach combined.

Extensive osteomyelitis involving the incisive portion (unilaterally or bilaterally) may create large and challenging ventral abscesses firmly attached to underlying bone. They require deep and thorough debridement (Fig. 3).

### *Periapical Infection of Distal Molar Teeth and Osteomyelitis of the Masseteric Fossa*

The most distal (caudal) mandibular cheek teeth (CT4 and CT5) can be affected by abnormal elongation of the reserve crown and periapical infection. CT5 is rarely

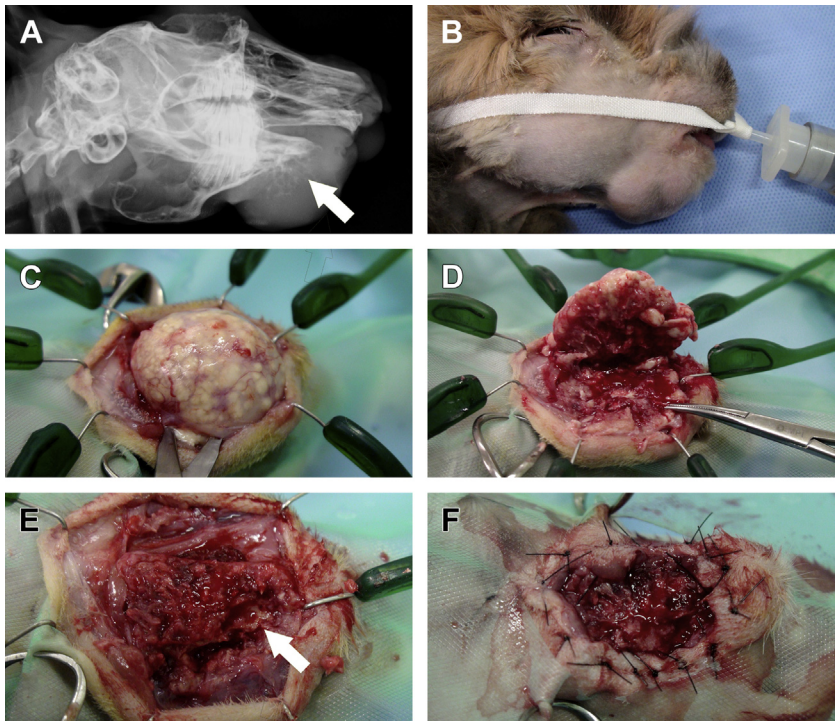


**Fig. 3.** Osteomyelitis of the incisive portion of the left mandible. This rabbit underwent extraction of the incisor teeth 6 months earlier because of malocclusion and periapical infection of the left mandibular incisor. (*A*) Right ventral to left dorsal 30° oblique projection of the head showing infection and periosteal reaction of the incisive part of the left mandible (*arrow*). The other oblique projection did not confirm involvement of the right incisive portion. (*B*) Clinical appearance of the abscess, which is well attached and non-mobile. (*C*) With the rabbit placed in dorsal recumbency, exposure of the abscess is performed after incision of the skin and blunt dissection of the overlying soft tissues. Note that this abscess does not have an overall capsule; it appears to be an aggregate of small abscesses. The bases of the abscesses are dissected free from the incisive part of the mandible. (*D*) When dissection is complete, removal exposes the underlying moth-eaten appearance of the osteomyelitic bone, including many pockets filled with pus. (*E*) The affected bone must be thoroughly debrided and flushed to the point of bleeding, for healing by second intention. Note the discolored portion of the bone, on the left side (*arrow*). (*F*) The overlying part of the skin is removed, and skin margins are simply apposed over the bone. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

primarily involved, but is frequently involved in conjunction with CT4.[1,4,5,34] Because of the normal curvature of their reserve crown, the apices of those teeth lie just cranial to the borderline between the body of the mandible and the masseteric fossa.[1] In the case of ADD of those teeth, caudal elongation of the reserve crown and perforation of the cortical bone occurs at the cranial aspect of the masseteric fossa. The periapical infection and the abscess develop beneath the masseter muscle, leading to a retromasseteric abscess.

The surgical treatment of a retromasseteric abscess is more challenging than a standard mandibular abscess involving the 2 more cranial portions of the mandible. The basic principles are similar, but in this case the abscess capsule lies beneath the double-layered masseter muscle, and the underlying thin bone is often lytic and perforated. Deep and thorough debridement of the diseased bone is not always feasible, and the risk of intraoperative complications (ie, fracture of the mandible during the debridement of the osteomyelitic bone) is higher. However, possible fracture of the mandible during debridement of this area may not be associated with poor prognosis because the masseter muscle can provide enough stabilization to allow the fracture to heal during the postsurgical period. Computed tomography is highly recommended before this surgery to evaluate the position of the diseased reserve crown and the extent of the lysis, and to rule out possible fracture of the branch of the mandible. Intraoral extraction of CT4 and CT5 should be attempted before the extraoral surgical procedure. However, complete extraction is unrewarding in most cases because the clinical or the reserve crown can fracture.

The skin incision over the swelling is performed in an oblique dorsoventral and craniocaudal direction. After gentle retraction of the skin, the superficial zygomatic muscle is exposed. Blunt dissection and retraction allow exposure of the aponeurosis covering the superficial part of the masseter muscle. The aponeurosis is then dissected and retracted to expose the body of the superficial masseter. The superficial and the deep parts are then dissected and retracted as well, until the white capsule of the abscess is exposed. The retromasseteric capsule is usually thinner than in other abscesses. The capsule is opened and removed along with the abundant pus. The diseased tooth or its remainder is extracted, but thorough debridement of the surrounding bone may not be feasible because it may be very thin and lytic. The author has performed 2 different variations of this surgical approach. In the past, thorough cleaning and flushing of the infected area followed by suturing of the muscle layers has been unrewarding. Relapse of infection may carry a poor prognosis, because the masseter muscle can be affected by necrosis and gangrene. Although the function of the masseter muscle is affected after complete incision and marsupialization, chewing does not seem to be affected. Food is masticated primarily in a horizontal or lateral plane by only 1 side of the cheek teeth at a time; therefore, the rabbit is able to chew with the contralateral muscle/teeth functional unit. The author currently performs and recommends this technique (**Fig. 4**).

### *Extensive Osteomyelitis of the Mandible*

Rabbits affected by advanced to end-stage dental disease may be presented with extensive osteomyelitis of the mandible.[2–5,34] Typically, 2 different stages of this condition can be encountered: (1) extensive osteomyelitis of the mandible involving the incisive portion and the body of the mandible, without involvement of the masseteric fossa; or (2) extensive osteomyelitis of the mandible involving the incisive portion, the body of the mandible, and the masseteric fossa.

In those cases in which most of the supporting bone is lytic and moth-eaten, usually with additional multilobed abscesses, thorough debridement is not sufficient to stop

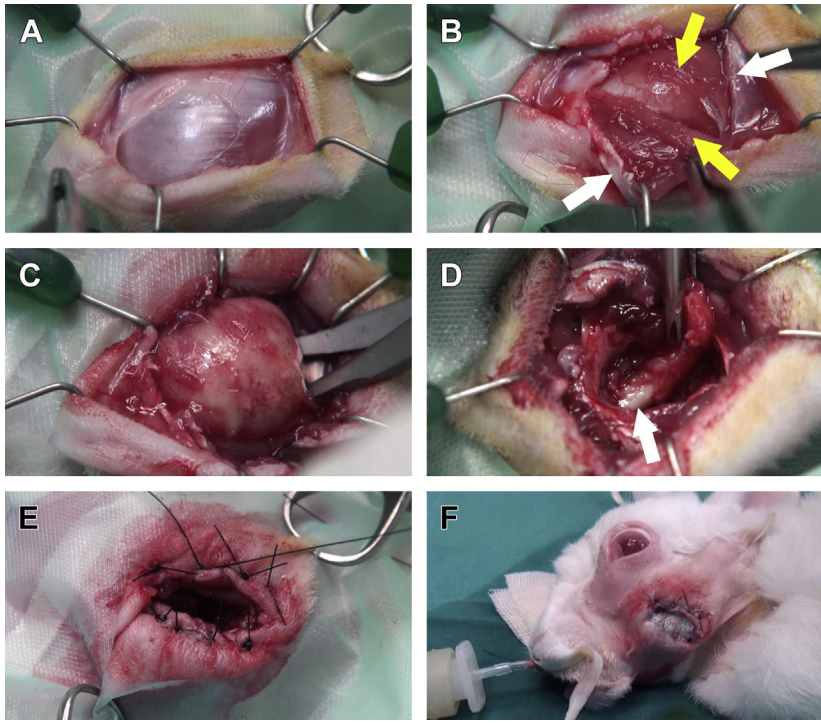


**Fig. 4.** Surgical treatment of a retromasseteric abscess, in the same case as shown in Fig. 1C. (*A*) Following incision and blunt dissection of the superficial zygomatic muscle, the aponeurosis of the masseter muscle is exposed using the Lone Star Retractor. (*B*) The aponeurosis and the superficial part of the masseter muscle are dissected and retracted (*white arrows*). The deep part of the muscle is dissected (*yellow arrows*) revealing the underlying capsule of the retromasseteric abscess. (*C*) The capsule of the abscess is dissected and removed, and the cavity cleaned and repeatedly flushed. (*D*) The affected tooth is extracted using an extraoral approach. Note the forceps grasping the elongated and L-shaped apex, and the clinical crown (*arrow*). (*E*) Marsupialization of the dissected layers is performed with nonabsorbable suture. (*F*) Cosmetic appearance at the end of the surgical procedure. The surgical site has been filled with HEALx Soother Plus cream. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

the infection. The involved portions of the mandible should be removed en-bloc. In the case of an intact, caudal masseteric portion of the mandible, unilateral rostral (partial) mandibulectomy can be a feasible treatment option (Fig. 5). In the second case, the surgical options can be subtotal unilateral mandibulectomy with transverse resection of the branch of the mandible, or total mandibulectomy. Computed tomography is mandatory to make a proper prognosis and a surgical plan. Mandibulectomy has also been reported in case of mandibular neoplasia.[35]

The steps of this challenging surgical procedure can be summarized as follows:

- The anesthetized rabbit is placed in lateral recumbency. During surgery, the dorsal recumbency also helps to expose the ventral and the medial aspects of the mandible.
- The area is shaved and surgically prepared as routine.
- A skin incision parallel to the long axis of the body of the mandible is performed.

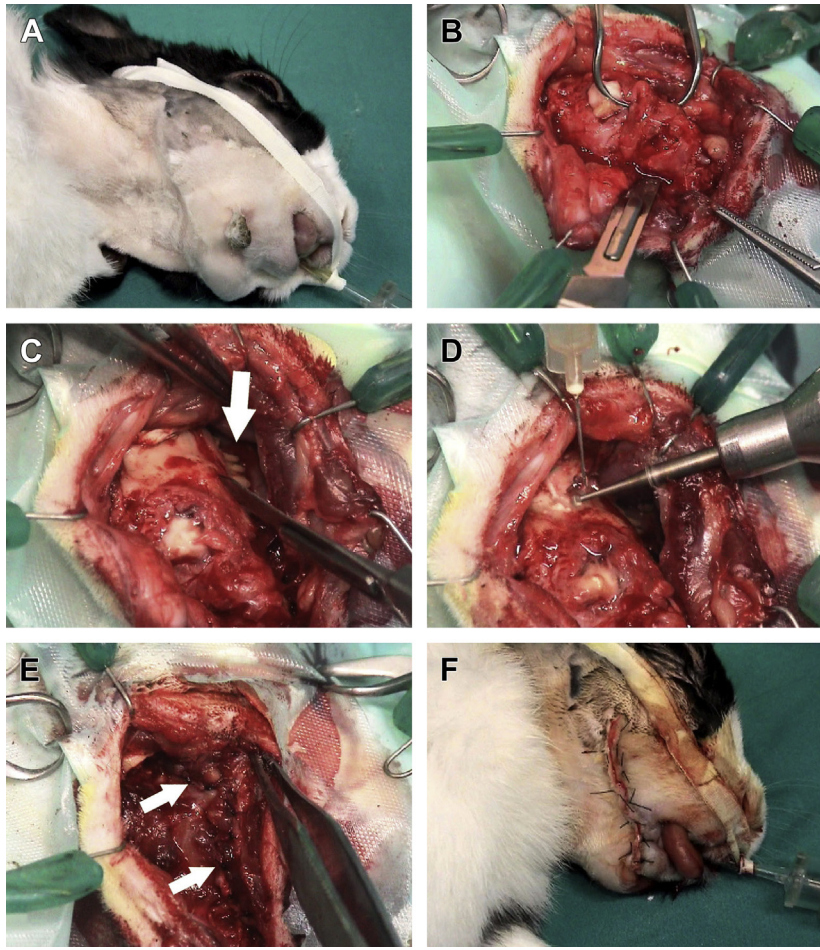


**Fig. 5.** Rostral right subtotal mandibulectomy. (*A*) The patient is placed in lateral recumbency for most of the surgical procedure, and converted to dorsal recumbency when necessary. Note the multiple abscesses following extensive osteomyelitis of the body and the incisive part of the mandible. (*B*) The deformed and moth-eaten osteomyelitic portion is widely exposed after dissection of overlying and surrounding soft tissues. The mandibular symphysis is separated using a scalpel blade. (*C*) Buccotomy is performed, dissecting the oral mucosa from the surrounding bone. Mandibular cheek teeth are visible (*arrow*). (*D*) The caudal aspect of the body of the mandible is dissected just cranial to the masseteric fossa with a ball-tipped bur mounted on a straight handpiece. After osteotomy of the mandible, the medial muscles are detached for the medial surface, and the diseased portion is removed. (*E*) The suture of the buccotomy is performed with absorbable 4-0 suture (*arrows*). The author prefers a simple interrupted pattern to reduce the risk of dehiscence. The overlying muscles and the skin are sutured as routine. (*F*) Cosmetic appearance at the end of the surgical procedure. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

- Overlying abscesses and infected tissue are dissected and removed.
- Exposure of the osteomyelitic bone of the body and the incisive part of the mandible, including exposure of the facial artery and vein, is made after blunt dissection of surrounding tissue, also on the ventral aspect of the mandible.

- The facial artery and vein are ligated.
- Separation of the mandibular symphysis is performed using a scalpel blade or a periosteal elevator. Attention must be paid to preventing fracture of the contralateral incisive portion of the mandible.
- Lateral buccotomy is performed by dissection of the buccal mucosa from the diseased portion of the mandible, to expose caudally all cheek teeth.
- Transverse osteotomy of the body of the mandible, just cranial to the border of the masseteric fossa, is performed with a small bur.
- The digastric muscle is gently dissected from the medial aspect of the mandible. At this stage, the diseased part of the mandible is free from surrounding tissues and is removed.
- The suture of the buccal mucosa is performed from the extraoral side in a simple interrupted pattern using a 3-0 absorbable suture (eg, polydioxanone).
- The overlying muscles are sutured over the defect.
- The skin incision is sutured as routine. Marsupialization or healing by second intention is not an option with this technique.

Techniques for subtotal and total mandibulectomy are even more challenging than for the rostral subtotal mandibulectomy, because detachment of the masticatory muscles medial to the masseteric fossa and ligation of the mandibular artery are required.

## POSTOPERATIVE CARE

Marsupialization allows postoperative flushing and treatment, and facilitates healing by second intention, reducing the risk of recurrence. Despite exposure of part of the deep bone, marsupialization is well tolerated by rabbits, and typically they do not need an Elizabethan collar or assisted feeding, usually being able to eat on the day after surgery.[2,4] Antibiotics and analgesics are administered as routine. Occasionally, anorexic rabbits must be encouraged to eat. Commercially available assisted-feeding products for herbivores are excellent for this purpose. Adjunct fluid therapy is necessary in some patients.

The local postoperative treatment consists of flushing the surgical site twice daily with further gentle debridement, applying antiseptics or other products to promote healing (**Fig. 6**).[1,2,4] The author prefers the use of healing-promoting cream containing quaternary ammonium suspended in aloe vera distillate and monoglyceride of fatty acid (HEALx Soother Plus, Lake Worth, FL). This wound care can be performed with gentle restraint and without the use of sedation or anesthesia. Most owners, following adequate instructions from the veterinarian, are able to perform part of the local treatment at home.

When a layer of granulation tissue begins to cover the exposed bone, the marsupialization suture is removed from the marsupialization site (typically 4–7 days postoperatively). At 3 weeks after surgery, the bone cavity fills with new connective tissue and other deep soft tissues are usually healed. Approximately 4 weeks after surgery, the overlying skin is completely healed (**Fig. 7**). Slow healing by secondary intention is also critical in cases of simultaneous extraction of 1 or 2 cheek teeth, in which suturing the gingiva may be difficult to impossible. In these cases, the alveolus may become impacted with food if the extraoral access is completed with a suture. Marsupialization allows flushing of the intraoral-extraoral fistula through the cutaneous opening, until the fistula closes after healing of the gingiva and extraoral soft tissues, and the apposition of new bone.

Intensive postoperative care of the wound should be performed with special care after marsupialization of the masseter muscle. Temporary exposure of the masseteric fossa leads to formation of a fistula that eventually heals by second intention[5] (**Fig. 8**).

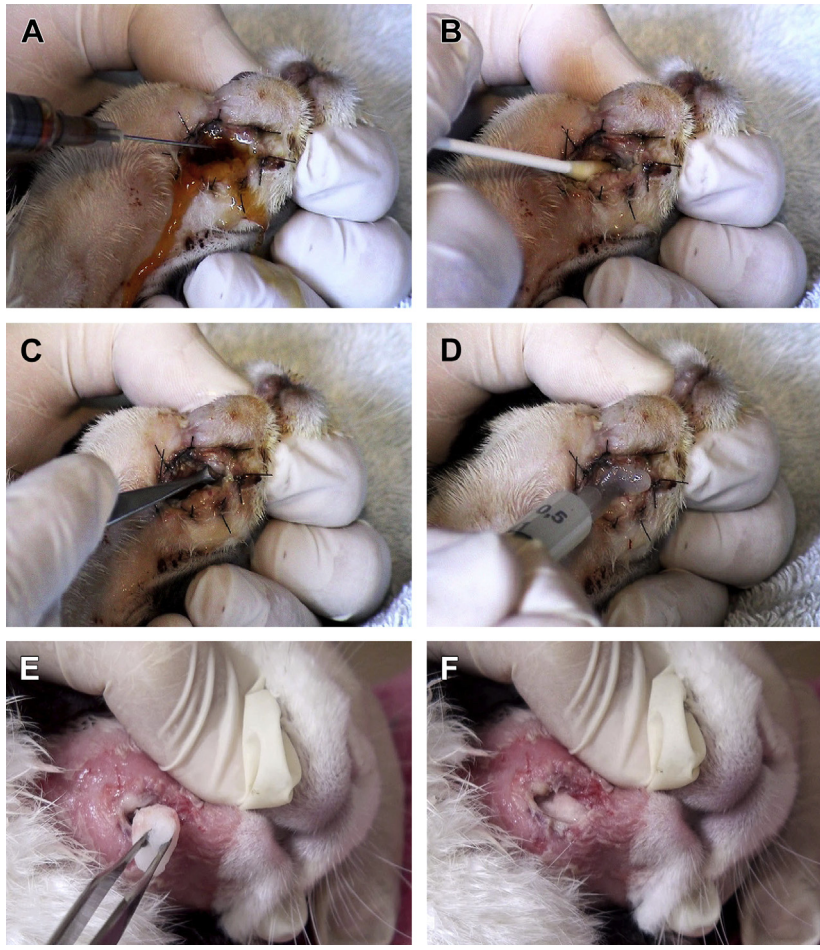


**Fig. 6.** Postoperative treatment after marsupialization of mandibular abscesses. The rabbit is manually restrained in dorsal (*A–D*) or lateral (*E*, *F*) recumbency without the use of sedation. (*A*) The surgical site and the bone cavity are flushed with saline or with 2% iodopovidone solution. (*B*) Debris and fibrin are removed using a cotton-tipped applicator. (*C*) Further gentle debridement is performed to stimulate bleeding of bone and soft tissues. (*D*) The area is flushed with saline, and healing-promoting cream is applied locally. (*E*, *F*) When an intraoral-extraoral fistula is present, a cotton ball wet with saline solution and impregnated with healing-promoting cream may be inserted to fill the bone cavity and prevent food debris from delaying the healing process. The cotton ball is replaced twice daily until the fistula closes. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

Edema of surrounding tissues is expected to some extent during the first days after rostral mandibulectomy. Complications include edema of tongue or dehiscence of the buccotomy suture.[5] The author has experienced several cases in which rabbits were able to eat soft food on their own within a few days after surgery.[5]

## FOLLOW-UP

Periapical abscesses and osteomyelitis are associated with a high rate of reoccurrence. Short-term follow-up shows healing of the surgical site and the surrounding

soft tissues (see Figs. 7 and 8; Fig. 9). Medium-term follow-up (8–12 weeks after surgery) includes radiographic evaluation to show remodeling and apposition of new bone in previous sites of osteomyelitis.[1]

## ABSCESSES OF THE MAXILLA AND EMPYEMAS OF THE SKULL

### *Odontogenic Non-periapical Abscesses*

Most odontogenic abscesses are periapical.[3,5] However, exceptions can be encountered. Coronal spikes of cheek teeth creating a wound on the buccal mucosa can develop into facial abscesses. Because of the typical pathophysiology of dental spikes, those abscesses are more likely to originate from maxillary cheek teeth. Extraction of the affected tooth is usually intraoral, and then complete surgical excision is performed as routine.

### *Periapical Infection of Maxillary Mesial (Rostral) Premolar Teeth (CT1 and CT2)*

This abscess, typically presenting with a swelling of the rostral maxillary area and epiphora, is commonly named maxillary abscess or zygomatic abscess.[1,5] Pathophysiology and combined intraoral dental/extraoral surgical treatment are similar to the corresponding abscess of mandibular premolars (Figs. 10 and 11). Adjunct local anesthesia can be achieved by performing a local nerve block of the rostral infraorbital

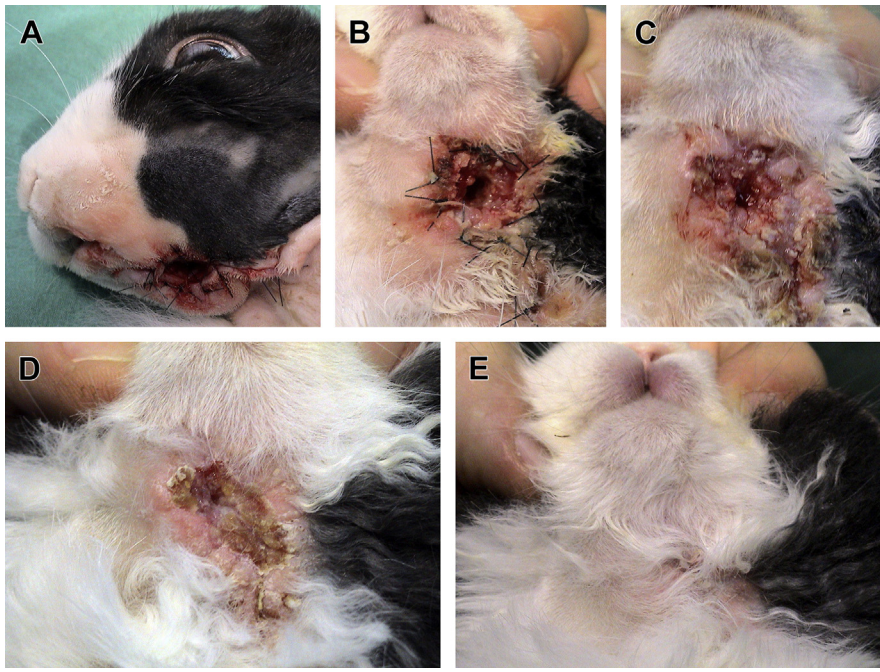


**Fig. 7.** Follow-up during the postoperative period following excision and marsupialization of a mandibular abscess. This patient was treated with local application of HEALx Soother Plus cream. (*A*) Marsupialization at the end of the surgical procedure. (*B*) Seven days after surgery, granulation tissue is present within the bone cavity and around the marsupialization site. (*C*) Ten days after surgery and suture removal, the stoma is reducing in size. (*D*) Eighteen days after surgery the surgical site is almost completely healed. (*E*) Four weeks after surgery, healing and fur regrowth are complete. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

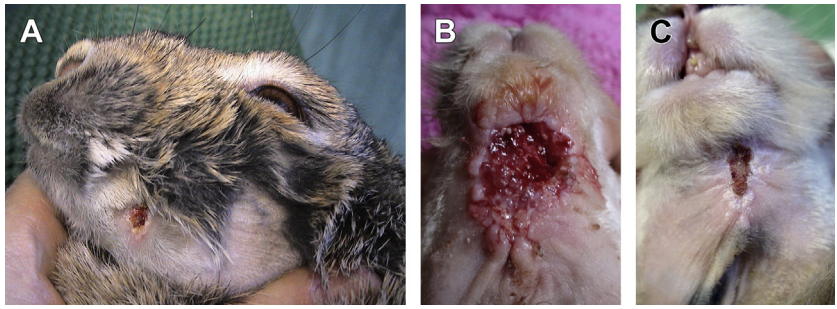


**Fig. 8.** Follow-up of surgical procedures shown in Fig. 2 (*A*) and Fig. 3 (*B*, *C*). (*A*) Follow-up 25 days after surgery. (*B*) Follow-up 17 days after surgical debridement shows formation of bleeding granulation tissue over the diseased bone. (*C*) Healing is almost complete 4 weeks after surgery. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

nerve.[32,33] Because of the different anatomy compared with the mandible, focal osteomyelitis may not be present. However, in advanced cases, it may also be complicated by dacryocystitis or by involvement of the maxillary recess.[3,5] Exophthalmos is usually absent.

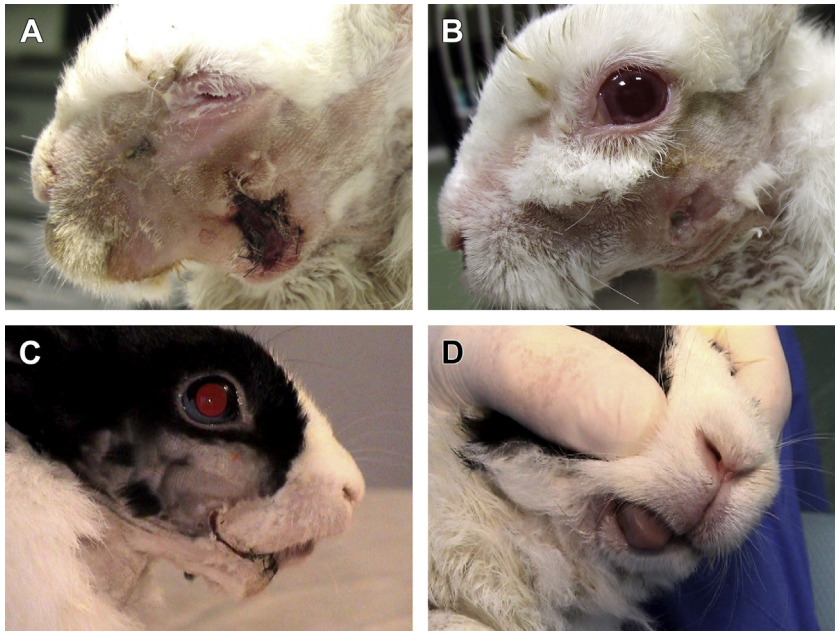


**Fig. 9.** Follow-up during the postoperative period of surgical procedures shown in Fig. 4 (*A*, *B*) and Fig. 5 (*C*, *D*). (*A*) Follow-up after 6 days and (*B*) 23 days. Further improvement progressed to complete healing and fur regrowth. (*C*) Follow-up after 10 days and removal of the skin suture. (*D*) Follow-up 35 days after rostral mandibulectomy. Mild protrusion of the tongue on the right side is caused by the lack of mandibular support, and did not affect the rabbit's eating and drinking capabilities. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

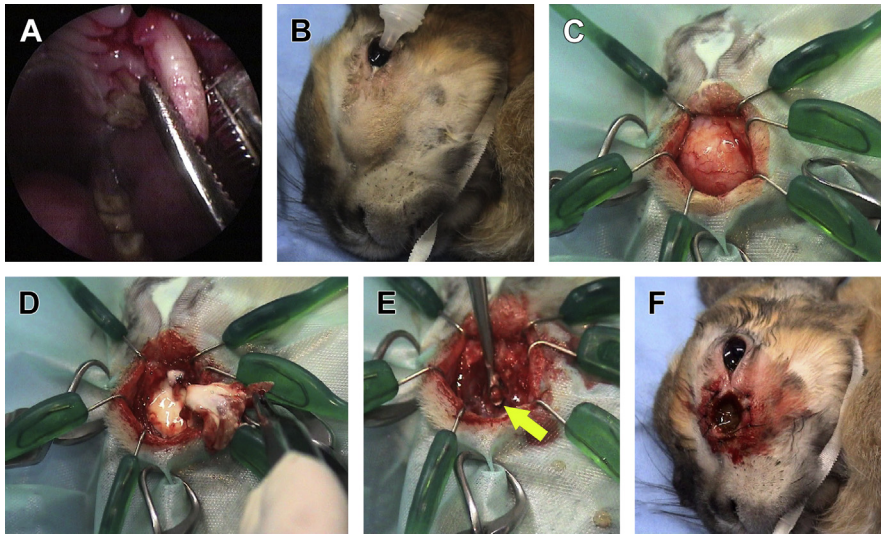


**Fig. 10.** Surgical treatment of a maxillary abscess, in same case as shown in Fig. 1D. (*A*) The diseased left CT1 has been completely extracted via an intraoral approach. (*B*) The rabbit is placed in lateral recumbency. The cornea is protected with ophthalmic lubricant before draping. (*C*) The abscess is exposed after incision of the skin, blunt dissection, and retraction of the surrounding soft tissues. (*D*) The capsule is dissected and removed, and the abscess is cleaned of pus. (*E*) The diseased area over the abnormal perforated surface of the maxillary bone is debrided. The fistula created by the periapical infection (*arrow*) is checked and cleaned using a Williger bone curette. (*F*) Marsupialization and cosmetic appearance at the end of the surgical procedure. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

### *Bacterial Dacryocystitis*

Bacterial infection of the nasolacrimal duct is usually odontogenic because secondary involvement (subocclusion or obstruction) follows overgrowth of reserve crown and apical deformity of the ipsilateral primary incisor tooth (more commonly), or of the rostral premolar teeth (less commonly).[1,5] It may or may not be associated with a periapical infection of those teeth, but even in the latter case it may develop into a facial abscess. Presentation is similar to the maxillary or zygomatic abscesses mentioned earlier.

Surgical treatment is designed for debridement and marsupialization, but abscess of the distal portion of the nasolacrimal duct involving the naris or the upper lip might require cosmetic surgery (see Figs. 11 and 16).

### *Periapical infection of molar teeth*

Bacterial involvement of several periocular structures (maxillary teeth, alveolar bulla, lacrimal glands), single or combined, can lead to the clinical sign of exophthalmos.[1,2,4,5] Those causes have all been generally reported as retrobulbar abscess. Even if this pathologic condition is common in pet rabbits as a complication of dental disease, a proper classification is useful not only because exophthalmos may show slightly different traits but because several different surgical approaches can be pursued, depending on the type of abscess. Advanced cases presenting late in the course of the disease result in loss of the eye globe and necessitate enucleation. This procedure allows dorsal surgical access to the alveolar bulla but also risks

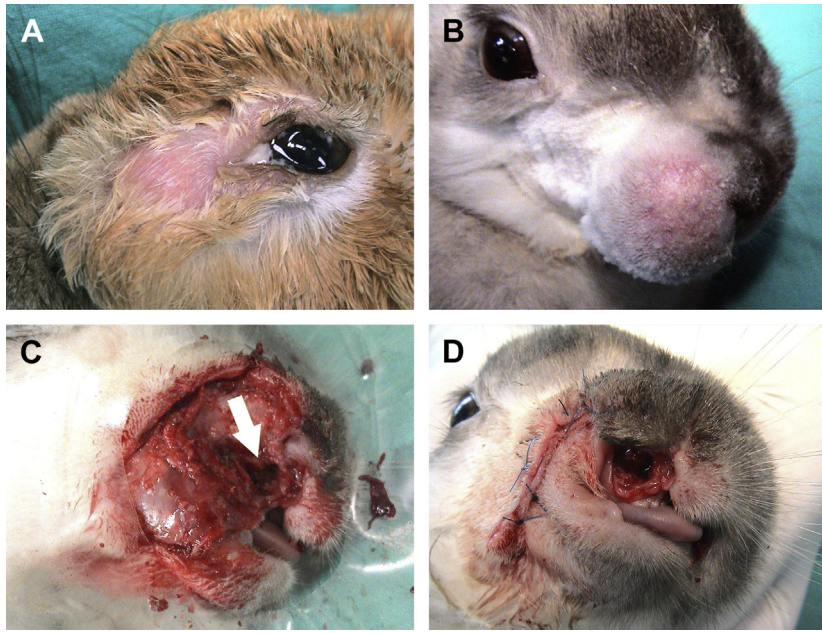


**Fig. 11.** (*A*) Odontogenic dacryocystitis and abscessation of the nasolacrimal duct. (*B*) Abscess involving the distal tract of nasolacrimal duct and the surrounding upper lip. This rabbit previously underwent extraction of incisor teeth. (*C*) Intraoperative stage after surgical excision, and core of the abscess (*arrow*). (*D*) A combined suture and marsupialization technique was performed to improve the cosmetic appearance at the end of the surgical procedure. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

exposure of the optic nerve and the optic foramen, and in addition is not ideal for cosmetic reasons. Detailed diagnosis and appropriate surgical access can allow resolution, saving the affected eye.

### *Deformity and Empyema of the Alveolar Bulla*

The alveolar bulla is a virtual cavity, because it is a preformed bony structure including the reserve crowns of maxillary CT3 to CT6.[2,4,5,7] In cases of elongation of reserve crowns, widened interproximal space, and apical deformity, the dome of the alveolar bulla can enlarge. In other cases, a small cavity can form within the alveolar bulla, in particular when a single cheek tooth has been previously extracted. It may partially fill with food debris and an empyema may follow. The result of this pathologic change is mild to intermediate exophthalmos, but a retrobulbar abscess is not present at this stage. Dedicated oblique projections, or advanced diagnostic imaging (computed tomography, MRI) are needed for differential diagnosis (**Fig. 12**). At least 3 different options can be considered to prevent formation of a retrobulbar abscess:

1. Flush the empyema intraorally. This option may not be practical, because repeated anesthesia is necessary and the empyema may not be resolved.
2. Extract all the cheek teeth and allow the inner surface of the alveolar bulla to heal by second intention.
3. Perform a lateral maxillotomy to access the alveolar bulla and fill the defect with AIPMMA beads.

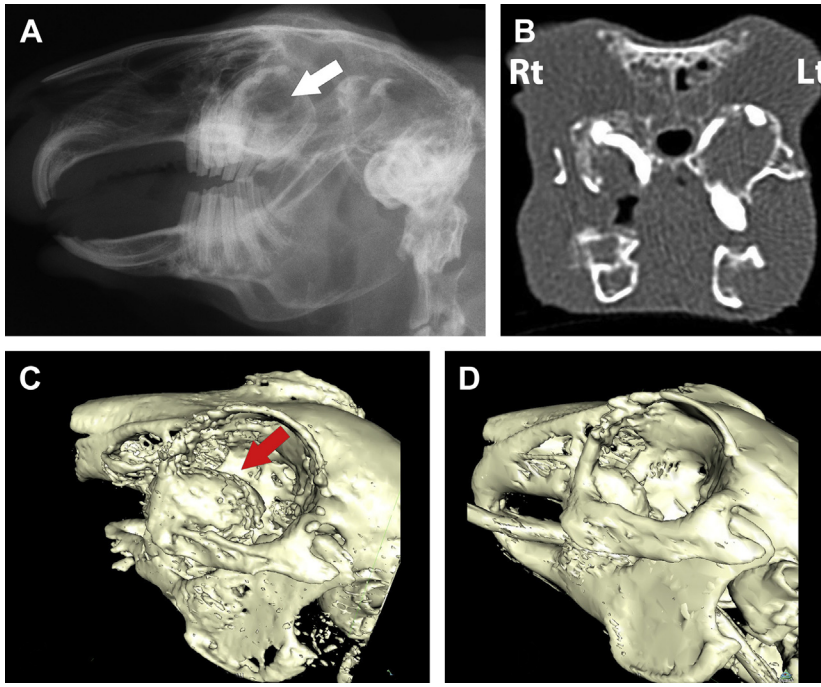


**Fig. 12.** Deformity and empyema of the alveolar bulla. (*A*) Radiography of the head, slight oblique view in the rostrocaudal direction, showing deformity of the alveolar bulla (*arrow*). This rabbit previously underwent extraction of the maxillary CT4. Note the gap between CT3 and CT5. This deformity, uncomplicated by a retrobulbar abscess, may or may not elicit mild exophthalmos. (*B*) Computed tomography of the head, axial view, in a different rabbit with advanced dental disease. Bilateral deformity and empyema of the alveolar bullae are visible, more evident on the left side. (*C*) Three-dimensional surface rendering of the same patient as in (*B*), emphasizing the enlargement and deformity of the left alveolar bulla (*arrow*). (*D*) Appearance of the normal alveolar bulla, for comparison. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

The steps of this surgical procedure can be summarized as follows:

- With the patient in lateral recumbency, shaved, and surgically prepared as routine, a skin incision is made followed by blunt dissection of the underlying soft tissues to expose the cranial third of the zygomatic arch.
- The insertion of the masseter muscle is dissected free from the cranial part of the zygomatic arch.
- Partial ostectomy of the cranial portion of the zygomatic arch is performed using a bur, the goal being to expose the lateral aspect of the maxillary bone and the alveolar bulla.
- The lateral osteotomy of the alveolar bulla is performed with the tip of a small bur.
- The cavitary alveolar bulla is flushed and cleaned. Small AIPMMA beads can then be introduced to fill the defect.
- The suture of the overlying muscular and cutaneous tissues is performed as routine. Marsupialization of this surgical site is not a practical option because the small linear opening is prone to closure.

However, in the author's experience, conservative treatment and monitoring of the deformity and/or empyema of the alveolar bulla can be an alternative option to the surgical approach, being prepared to address the retrobulbar abscess should the empyema progress to a further stage.

### *Retrobulbar Abscess*

A retrobulbar abscess originates from periapical infection and perforation of the dome of the alveolar bulla.[2,4,5,34] The abscess can be as large as the eye globe, and the position is exactly at the bottom of the orbital fossa, therefore ventromedial to the eye globe. Pressure usually elicits an obvious and severe exophthalmos that can rapidly evolve to panophthalmitis, with possible damage to the optic nerve. Radiography including several oblique views is diagnostic regarding the involvement of teeth and the alveolar bulla, but provides little information about the size and position of the abscess. Computed tomography and/or MRI are important for diagnosis and surgical planning. Computed tomography allows detection of the cheek teeth involved and more details about the alveolar bulla, whereas MRI provides the precise size and position of the retrobulbar abscess, including the optic nerve. Ideally they should be performed in combination; however, when only 1 is an option, MRI is more specific.

A combined intraoral and extraoral surgical approach is needed for a salvage procedure of the eye. Extraction of the affected cheek teeth (sometimes involving the entire maxillary arcade) is mandatory. Following extraction, the access to the retrobulbar abscess may[36,37] or may not be feasible, because the top of the alveolar bulla may not be reached through the intraoral approach. When the retrobulbar abscess is very large and dislocation of the eye globe is very dorsal, a lateral approach slightly dorsal to the lateral margin of the orbital fossa can be attempted (**Fig. 13**), as described later for the lateral parabulbar abscess. Depending on periorbital edema, immediate reposition of the eye globe may or may not be possible. Even in the latter case, postoperative antiinflammatory treatment can be effective to improve the exophthalmos.

### *Parabulbar Abscesses*

Periapical infection with subsequent involvement of the accessory lacrimal gland leads to a lateral (or infraorbital) parabulbar abscess.[5] Because exophthalmos is evident and severe, these abscesses have usually been reported as retrobulbar. However, the difference is critical because the abscess is not located at the bottom of the orbital fossa, and surgical access can be successfully achieved with a ventrolateral approach to the exophthalmic eye globe. Repositioning of the eye globe is accomplished after removal of the pus, debridement, and thorough flushing. Marsupialization of this surgical site is not a practical option because the small linear opening is prone to closure. However, part of the incision may be left open, allowing flushing for a few days postoperatively (**Fig. 14**; see **Fig. 16**).

Periapical infection with subsequent involvement of the main lacrimal gland leads to a caudal parabulbar abscess. Surgical debridement is straightforward, with a caudal approach to the eye globe.

### *Empyema of the Maxillary Recess*

An empyema of the alveolar bulla (or a periapical infection of premolar teeth, with or without concurrent involvement of the nasolacrimal duct) can spread to the adjacent maxillary recess.[5,7,8] Depending on individual patients and further development, clinical signs can be more consistent with an ipsilateral rhinitis, or with a swelling of the infraorbital area. The empyema of the maxillary recess may require a double or triple combined surgical access: intraoral extraction of diseased cheek teeth, an extraoral

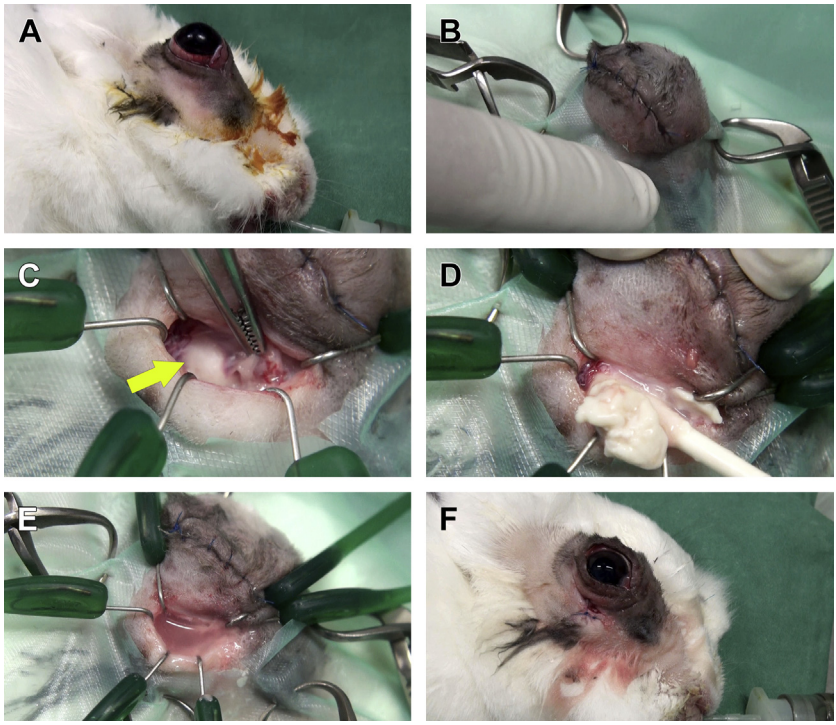


**Fig. 13.** Lateral approach to a retrobulbar abscess. (*A*) Exophthalmos, conjunctivitis, and episcleritis following a large retrobulbar abscess. (*B*) The cornea is protected beneath the surgical drape with a temporary suture of the eyelid. The surgeon's finger palpates the lateral dome of the abscess. (*C*) A skin incision has been performed just below the exophthalmic eye globe and just above the zygomatic arch. The normal intact accessory lacrimal gland (*arrow*) is exposed after blunt dissection and retraction. (*D*) Beneath the gland, incision of the abscess is performed, and a large amount of pus is removed using cotton-tipped applicators. The abscess cavity is thoroughly flushed. (*E*) After the abscess cavity is emptied, the exophthalmos is reduced. (*F*) Marsupialization of this surgical access is not a practical option because the small linear opening is prone to closure, so the skin incision is partially closed. In this case, the eye was repositioned at the end of the surgery. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

approach through the perforated area of the maxilla (pararhinotomy) (**Figs. 15** and **16**), and/or a dorsal approach via a rhinostomy. The pararhinotomy and rhinotomy techniques have been reported in the literature.[8]

### *Empyema of the Nasal Cavity and Odontogenic Septic Rhinitis*

Chronic septic rhinitis secondary to severe or end-stage dental disease can be a sequela of empyema of the alveolar bulla and/or empyema of the maxillary recess.[5,8] Long-term medical treatment is usually unrewarding, but it can provide temporary and palliative improvement. The rhinotomy approach followed by temporary or permanent rhinostomy has been reported in the literature.[8,38,39]

### *Empyema of the Tympanic Bulla/Otitis Media*

Empyemas of the alveolar bulla, maxillary recess, and/or nasal cavities can spread the infection to the tympanic bulla through the pharynx and the eustachian tubes.[5,14,34]

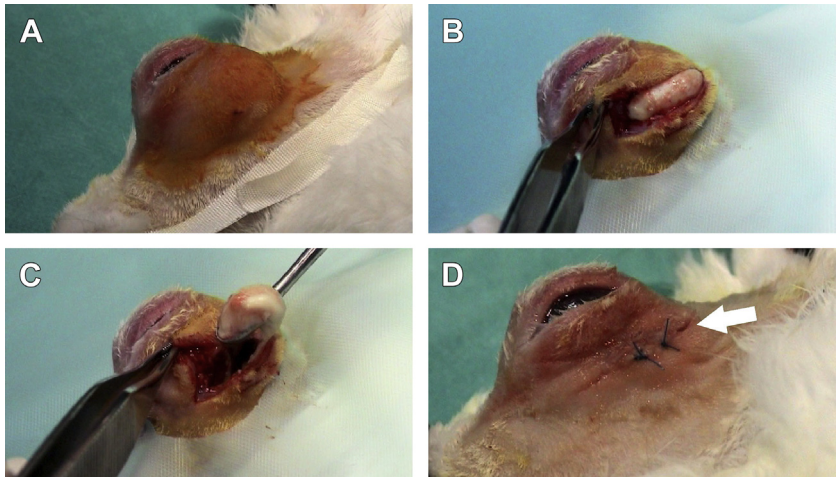


**Fig. 14.** Lateral approach to a parabulbar abscess. (*A*) Same case as shown in Fig. 1F, scrubbed with 5% diluted iodopovidone solution. (*B*) After the skin incision, the abscessed accessory lacrimal gland is entered. In this case, a thick capsule was not present. (*C*) The pus is removed using cotton-tipped applicators and a Williger bone curette. (*D*) The eye globe is repositioned, and the suture is closed leaving a small part open (*arrow*) for postoperative flushing. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

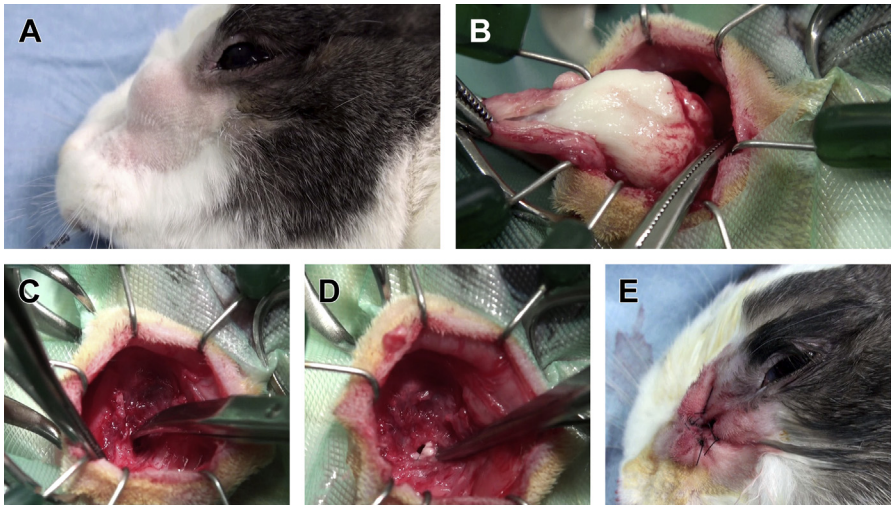


**Fig. 15.** Surgical excision of a maxillary abscess and pararhinotomy for treatment of the empyema of the maxillary recess. (*A*) In this rabbit showing an ordinary maxillary abscess, computed tomography showed the underlying empyema of the maxillary recess. (*B*) The abscess is exposed and excised as routine. (*C*) A small fenestration, which represents a pararhinotomy, is created over the abnormal diseased portion of the perforated surface of the maxillary bone. The thin bone can be entered using the tip of sharp scissors. (*D*) The maxillary recess is emptied by flushing, or using a Williger bone curette. (*E*) Marsupialization of the surgical site allows postoperative flushing of the recess until healing of the overlying soft tissues. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

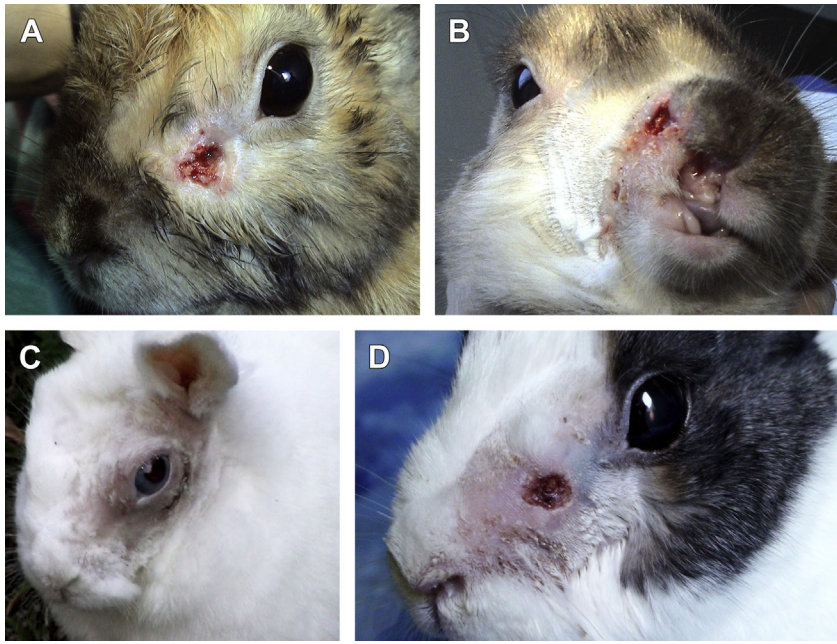


**Fig. 16.** Follow-up during the postoperative period of surgical procedures shown in Fig. 10 (*A*), Fig. 11 (*B*), Fig. 14 (*C*) and Fig. 15 (*D*). Further improvement progressed to complete healing and fur regrowth. (*Courtesy of* Vittorio Capello, DVM, Milano, Italy; with permission.)

Empyema of the tympanic bulla may or may not be clinically evident as otitis media with neurologic signs and symptoms, and these patients may or may not be affected by concurrent otitis externa. The surgical approaches and techniques for treatment of the tympanic bulla have been extensively reported.[40–44]

## SUMMARY

Facial abscesses associated with periapical infections and osteomyelitis of the jaw are frequent in pet rabbits affected by acquired dental disease. Retromasseteric and retrobulbar abscesses, extensive osteomyelitis of the mandible, and empyemas of the skull represent possible further complications. Definitive therapy requires surgical treatment via numerous extraoral and facial approaches, depending on the exact diagnosis, position, and anatomic structures involved.

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