Peri-operative care and instrumentation
Any job is done better when the proper tools are available. Likewise, surgery is much easier when the appropriate instruments are available. In addition, ophthalmic surgery is much easier, and the results much more consistent and rewarding when certain peri-operative protocols are followed.

Preparation of the Surgical Site
Eyelid skin and conjunctiva are very sensitive to mechanical and chemical irritation. Chemosis and erythema of the eyelid skin and conjunctiva is commonly seen with overzealous clipping and cleansing of the surgical site. This tissue swelling can greatly distort the surgical site, leaving the surgeon with a difficult exposure for the intended procedure. In the case of surgery of the ruptured or nearly ruptured globe, excessive manipulation and inappropriate disinfection techniques can make the condition worse. Irritation of the surgical site can also lead to postoperative patient attempts at self-trauma.

Removal of hair from the lids and peri-ocular skin is the first step in the preparation of the surgical field. The #40 or #50 clipper blade on a standard set of clippers does a nice job of removing hair about the face and even on the eyelids themselves. Blades that are not sharp may result in "pulling" of the hairs with resultant "clipper burn", seen as swelling and irritation of the clipped area. Excessive "scrubbing" of the site with the edge of the blade to get all of the fine and short hairs may also result in excessive skin irritation. Fine, 3/4" wide mustache clippers can be used to clip hair in tight corners and may be less irritating than standard #40 blade clippers. In conditions of globe rupture or near rupture, pressure on the globe from clippers as well as scattering fine hair stubble in the surgical field is definitely contraindicated. Scissor clipping is also utilized by many for the removal of hair in preparation for ophthalmic surgery (especially in the preparation of the eye for corneal laceration or descemetomecle surgery). A pair of fine (1"") Metzenbaum or a Steven's tenotomy scissor works nicely. The edge of the scissor can be coated with a light coating of K-Y jelly to make the hair stick to the scissors as hair is being clipped, thus lessening the cleanup of the fine hair at the surgical site. One must take extreme care in using scissors, because it is very easy to cut the surface of the skin, eyelid margins, etc. when trying to get close to the skin. Wearing loupes or 3-diopter reading glasses while trimming hair helps reduce accidental nicks, and allows for very close hair removal. Prepping a large periorcular area improves post-operative hygiene and increases owner compliance for keeping the peri-ocular area clean.

Cleansing and disinfection of the cul-de-sacs, eyelids, and skin is the next step in preparation of the surgical site. Using Q-tips and gauze sponges to cleanse the cul-de-sacs and lids/skin with 1:20 to 1:40 dilute povidone-iodine solution in physiologic saline or sterile eyewash (0.5% to 0.25% final concentration) results in adequate disinfection of the surface tissues with minimal irritation to cornea, conjunctiva, or skin. I also routinely begin systemic broad-spectrum antibiotics beginning 12-24 hours prior to most eyelid surgery and continue for at least 3-7 days postoperatively. Dilute povidone-iodine can be used to gently cleanse the globe surface as well as the conjunctiva followed by saline rinse. **Soap-containing iodine scrubs and alcohol have no place in the preparation of any surfaces near the eye.** In cases of corneal laceration and iris prolapse, I routinely cleanse lids and cul-de-sacs as usual, taking care not to put excessive pressure on the damaged globe, and liberal flushing of the corneal surface is performed with sterile saline. If the incarcerated iris is necrotic, it is amputated instead of trying to "clean it up" and replace it into the anterior chamber.

Positioning and draping are the final preparation steps for ophthalmic surgery. I tend to use some sort of a modification of lateral recencyency for orbital or eyelid surgery. For procedures on the third eyelid, conjunctiva, or globe itself, I personally prefer to position myself “over the top” (patient in dorsal recencyency, me at the top of the head) with my assistant to my left (I am right handed). Draping can be with four-corner towel draping, cloth aperture drapes, or paper drapes with an aperture cut by the surgeon to suit the need. For corneal or intraocular surgery, the use of a de-powdered surgical glove or a self-adhesive...

**Instrumentation and Suture Materials**

Fine Adson forceps with tying platform, #3 or #9 Bard-Parker handle with #15 Bard-Parker blade, fine (1” blades) Metzenbaum scissors, Derf needle holder (larger needle holder for #3-0 suture needles or larger), Jaeger lid plate; these instruments are considered the minimum equipment needed for basic eyelid surgery. Additional special instruments for corneal, conjunctival, and third eyelid surgery include (available through http://acrivet.com, http://www.msiprecision.com, www.SontecInstruments.com, and others): Barraquer lid speculum (5 mm very small dog/kitten, 10 mm medium dog/cat, 15 mm large dog), Steven’s tenotomy scissors (short, ~19 mm blades), Bishop-Harmon forceps (0.5, medium and 0.3, fine), Castroviejo tissue forceps (0.5 or 0.3 with a tying platform) or Colibri forceps (0.4 with a tying platform), Castroviejo needle holders (medium, curved with lock), Beaver handle (for #64, #65, or #67 blades), cotton-tipped applicators (sterilized Q-Tips® are my favorite for blotting and for hemostasis around the eyelids), and cellulose intraocular sponges (Weck™ sponges).

Appropriate sized suture/needles are important for a good surgical outcome. Monofilament nylon, braided nylon, and even silk can be used to suture the skin (cutting, swaged-on needles work best). The deeper layers of the lids can be sutured with polyglycolic acid. Chromic gut seems to be too irritating for use in eyelid surgery (personal preference). PDS suture is too “rigid” for ophthalmic surgery (also personal preference). Suture sizes include 4-0 or 5-0 for external skin suturing, and 4-0 to 6-0 for buried, absorbable sutures. For corneal closure or suturing of conjunctival flaps to the cornea, 7-0 or 8-0 PGA (Vicryl™) is good. The sutures should be double armed (needle at both ends) with a fine ophthalmic spatulated needle.

Microsurgery requires magnification. For many extraocular procedures, 2X magnification can be adequate. As the surgeon becomes presbyopic, simply being able to see relatively close up is very beneficial. A 3, 4, or 5 diopter single lens OptiVisor™ head loupe allows most previously emmetropic surgeons to focus at 13, 10, or 8 inches, respectively. Although 8-10 inches is a little close for doing most surgery, this little bit of help can cheat Father Time enough for many lid procedures. A really inexpensive alternative is 3 diopter readers from the grocery store. For actual microsurgery (corneal surgery, conjunctival grafts, even “cherry eye replacement” surgery), placement of needles/suture and fine tissue handling requires the 2.5 - 5.5X magnification of Galilean surgical loupes. Many companies make high quality loupes (Keeler, SugiTel, Zeiss, Heine, and others). Throughout my career I have used 4.5X Keeler loupes mounted on a glasses frame (even had bifocals put in the frames as I grew older;-). Some surgeons like the band mounted loupes so they can use their regular eyeglasses under the loupe. A mounted coaxial light source is very beneficial for ophthalmic surgery, but a band mounted light source worn over my glasses mounted loupes has been my standard for over 20 years. Loupes do not take the place of an operating microscope, but for most extraocular procedures, 3.5X or above magnification with loupes will do. In an emergency, a 3-diopter reader and a headlamp may get you through a simple procedure.

**Postoperative care**

Temporary tarsorrhaphy (split thickness horizontal mattress sutures of 4-0 or 5-0 nylon over rubber band stents) is very useful for the immediate post-operative period to protect globe and support conjunctival flap or corneal laceration repair. Once awake, a protective Elizabethan collar prevents self-trauma.

**Eyelid laceration/basic wedge eyelid resection**

Full thickness eyelid lacerations roughly perpendicular to the eyelid margin are commonly seen due to fight wounds and other sharp trauma. Proper closure will result in a functional eyelid that can cover the globe and maintain a tear meniscus and a cosmetically pleasing palpebral fissure. The basic technique for eyelid laceration closure may also be used to remove a full thickness eyelid tumor or to shorten an eyelid margin for correction of ectropion. The skin, stroma, and conjunctiva of the eyelids are very vascular, and minimal debridement of damaged tissue following an eyelid laceration is recommended. Following surgical preparation of the skin and conjunctival surfaces, minimal debridement with a scalpel blade to the point of the wounded surfaces beginning to hemorrhage is all that is necessary. Fine, absorbable suture (6-0
Vicryl™ is used to appose the edges of the lacerated tarsal plate. The first bite of the needle should enter the tarsal plate away from the lid margin and exit the tarsal plate close to the lid margin edge of the tarsal plate. The needle is then passed to the opposite side of the wound and passed into the tarsal plate in the area closest to the lid margin to exit the tarsal plate away from the lid margin. If done properly, the suture pattern approximates a horizontal mattress pattern with no suture passing through the palpebral conjunctiva (therefore there will be no possibility of suture rubbing the cornea) with the knot being tied and buried within the eyelid stroma away from the eyelid margin. A continuous pattern away from the eyelid margin finishes closure of the palpebral tarsal plate/conjunctiva with the final knot being buried within the eyelid stroma. If the eyelid stroma is excessively swollen, or the patient is a large dog, additional simple interrupted sutures to close the more external orbicularis oculi muscle may be in order. Skin closure must be meticulous at the eyelid margin so as to result in a smooth, physiologic eyelid margin. Three different suture patterns have been described to appose the eyelid margin skin. A simple horizontal mattress pattern using fine (4-0 to 6-0) non-absorbable (silk or braided nylon) suture followed by simple interrupted skin sutures results in excellent closure of these skin defects and is the pattern of choice for this author. A cruciate or “figure of eight” suture involving the lid margin followed by simple interrupted skin sutures also results in excellent closure. A well placed simple interrupted suture at the lid margin with the suture tags being tied back by subsequent simple interrupted sutures can result in excellent physiologic closure as well, but it is important to tie the suture tags back in a manner that does not allow the suture tags or the knot to come in contact with and abrade the corneal surface. If the closure is precarious due to tissue friability and/or swelling, temporary tarsorrhaphy sutures, one on either side of the wound closure, can help immobilize the lids and “splint” the lid until healing is complete and sutures are removed 10 days postoperatively.

Eyelid masses may be removed using a wedge-resection or “house-top” full thickness lid margin excision. Closure of this excision is the same as for an eyelid laceration. The average dog has enough length of lid to accommodate the removal of one-quarter to one-third of full thickness lid/margin using this technique without permanent cosmetic blemish or loss of function. Toy dogs with small palpebral fissures and cats may not tolerate more than one-quarter of the lid length being removed and primarily closed without noticeable cosmetic/functional defect. When excising the mass, incision through the lid margin must be perpendicular to the lid margin, with the two incisions medial and lateral to the tumor being parallel past the level of the tarsus/tarsal plate. The remainder of the full thickness excision through the lid skin, stroma, and conjunctiva should taper to the depth of the cul-de-sac to insure a smooth closure without bunching of the tissue following closure. This is best performed with the aid of a Jaeger lid plate to tense the lid tissue and scalpel through the skin and orbicularis muscle and a fine scissor through the palpebral conjunctiva. Closure is the same as for an eyelid laceration. In the case where the area of excised lid is greater than what can be closed without loss of function or disfigurement, a lateral canthotomy may be performed to allow the remaining lid tissue to be slid medially while the primary excision site is closed. In the case where more lid margin must be excised than can easily be closed (50+% of the lid in most dogs), a semicircular flap technique (Veterinary and Comparative Ophthalmology 1994, 4:93-103) may be used to close the void. With this technique, the skin and some muscle lateral to the operated lid is undermined following a skin incision that approximates an arc similar to the lid margin opposite the excised lid. At the distal end of this skin incision, a Burrow’s triangle is excised with the sides of the triangle equal to the amount of skin removed from the excised lid. After primary closure of the wedge resection, the skin/muscle is slid medially and the subcuticular tissue is closed with absorbable suture material. The Burrow’s triangle is sutured, and the skin is sutured in routine fashion. Temporary tarsorrhaphy sutures are placed on either side of the wedge excision site and at the “new” lateral canthus. I have successfully closed defects of up to 50% in cats and up to 2/3 of upper lid defects in dogs using this technique.

Entropion
Entropion is an enrolling of the eyelid margin with frictional irritation to the conjunctival and corneal surfaces. Entropion may be broken down into numerous forms (lower lid, upper lid, lateral canthal, and medical canthal), and different surgical procedures are needed for repair of each form.

Spastic entropion is usually seen in puppies (such as Shar Peis, Chows, and other “wrinkly breeds”). The uninformed or new breeder may present a 4-8 week old puppy with blepharospasm, epiphora, and corneal disease indicating that the puppy’s eyes “never opened” at 2 weeks. As the physiologic ankyloblepharon resolved at 2 weeks of age, the excessive weight and laxity of the puffy lids and loose skin results in enrolling of the lids and corneal irritation with subsequent blepharospasm which causes more enrolling, a vicious cycle. After topical anesthetic application, many of these puppies will relax the spasming somewhat, allowing for better examination. However, topical anesthetic is mildly epithelial toxic, and should never be used therapeutically. Surgical correction for spastic entropion involves a temporary eyelid eversion, using vertical mattress or horizontal mattress sutures to evert the lid margins away from the corneal surface. Personal preference dictates the type of suture used. I prefer multiple small (5-0 Prolene, the blue suture is easier to see when removing them 7-14 days later) sutures versus one or two larger sutures. This technique may be repeated if necessary while waiting for the puppy to reach a larger size for a more permanent correction at 3-9 months of age. Occasionally, older dogs that have never had entropion problems will experience spastic entropion, and this eyelid eveting technique may help reduce pain and blepharospasm while the underlying cause of pain in the older dog is addressed. Likewise, this temporary suture technique may be useful to treat herpes infected older cats that have dramatic spastic entropion while awaiting the effect of topical or systemic anti-viral therapy.

Simple lower lid entropion is best corrected by a modification of the Hotz-Celsius procedure. Some tips for this surgery that are useful to me are use of a Jaeger lid plate with an assistant to help position and tense the lids while the surgeon tenses the skin horizontally with thumb and index finger, and a scalpel is used to precisely incise the skin. Incision closest to lid margin should be along the haired/non-haired junction with the incision extending beyond the enrolled area. Second incision should be at the line where the skin was rolled in. This may be noted by a change in hair color, skin color, etc. if chronic. It is important to evaluate the relaxed patient (not sedated or anesthetized) with topical anesthetic applied to reduce spastic entropion. Following the “D-shaped” incision, skin is removed with scalpel or fine scissors (I prefer scalpel). The skin is closed with multiple simple interrupted Prolene sutures (some ophthalmologists close these with 5-0 Rapide™ PGA and do not remove sutures later. This is especially useful in vicious dogs that you don’t want the pleasure of having to deal with again!). If spastic entropion was significant pre-op, some temporary everting sutures (see “lid tacking” above) may be used to prevent suture tags abrading the cornea. An Elizabethan collar should be used until the sutures are removed.

Upper lid entropion is usually seen in dogs with excessive and lax forehead skin (Bloodhounds, Shar Peis, Neapolitan mastiffs, etc.) Many of these dogs also have lateral canthal entropion and lower lid ectropion. A large Hotz-Celsius procedure on the upper lid, or a combination lateral canthoplasty and upper lid Hotz-Celsius procedure can help these patients. In severely afflicted patients, a stellate rhytidectomy may be needed to “face lift” the patient (J Am Anim Hosp Assoc 1997;33:342-345).

Lateral canthal entropion is commonly seen in large breed dogs (St. Bernard, mastiff, Newfoundlands) that have lax lateral canthal ligamentous structures as well as heavy facial skin and macropalpebral fissures. In dogs without macropalpebral fissures (Chows and Shar Peis), a lateral canthal “arrow head” technique in conjunction with an upper and lower Hotz-Celsius technique is useful. The lateral retraction of the lateral canthus with “straightening” of the lid margins along with lid margin eversion many times is necessary for correction. In the larger dogs with the macropalpebral fissures, the lateral entropion, lower lid ectropion, and upper lid notching (“pagoda eye” or “diamond eye”) requires lateral traction of the lids along with shortening the macropalpebral fissures. A technique I have used successfully that pulls the canthus laterally and reduces the palpebral fissure size is a modification of Bigelbach’s technique (Vet Comp Ophth 1996;6:220-224). This technique involves removal of lateral canthal skin as well as full thickness excision of lid to shorten the palpebral fissure. The excised upper and lower eyelids are retracted and the tarsal plates are anchored to the orbital ligament structures, followed by
skin closure. This shortens the wide palpebral fissure as well as correcting the lateral entropion and lower lid ectropion, resulting in better lid conformation and better holding of tear film onto the corneal surface.

“Cherry Eye” Replacement
Iatrogenic keratoconjunctivitis sicca (KCS) is not as common as in years past, but still occurs. Chronic sulfonamide antibiotic therapy, chronic etodolac therapy, and third eyelid gland amputation remain 3 iatrogenic causes of KCS that can be permanent with long-term management issues. In a classic retrospective study by Dr. Rhea Morgan (JAAHA 1993; 29: 56-60), the cause and effect of amputating the third eyelid gland (“cherry eye”) with subsequent KCS problems is pointed out. In their 10 year retrospective study, ~68% of their KCS cases had a “cherry eye” amputation. About 16% of the KCS cases had a chronically prolapsed third eyelid gland, but only 11% of their KCS cases had a “cherry eye” replacement surgery performed. Another way to look at their data is that 48% of dogs studied with an amputated “cherry eye” developed KCS, 43% of dogs with a chronically prolapsed third eyelid gland developed KCS, and only 14% of dogs having a replaced third eyelid gland ultimately developed KCS. There are numerous techniques reported for replacing prolapsed third eyelid glands (JAAHA 1993; 29: 56-60, JAVMA 1994; 205:1412-1413, Vet Ophth 2014; 17: 81-86). The individual clinical case as well as surgeon preference is involved in the decision of which procedure to use. Since the incidence of KCS with third eyelid gland amputation is 3-4 times higher than with gland replacement, replacing the gland is preferred over taking a chance of dooming a dog to a life of dry eye problems. In the Stanley, Kaswan technique (JAVMA 1994; 205:1412-1413), the prolapsed gland is “anchored” to the periosteum of the ventral orbital rim using a buried monofilament nylon suture. This technique is quick, requires minimal special instrumentation, but can partially immobilize the third eyelid. The Morgan technique (JAAHA 1993; 29: 56-60) is an “imbrication” technique where the conjunctiva of the third eyelid is dissected and closed in a manner to retropulse the prolapsed gland ventrally. This technique allows for full mobility of the third eyelid, but may require more micro-dissection and microsurgical instrumentation than other techniques. In dogs with loose orbital and adnexal tissues (Neapolitan Mastiffs, English bulldogs), this technique has more potential to fail than some of the “anchoring” techniques. There are many minor modifications of Morgan’s original technique (see Dr. Abrams’s “reinforced technique” on YouTube, “cherry eye replacement, canine”, https://www.youtube.com/watch?v=pGLJyFi2YAA), but they all involve retropulsing the prolapsed gland by imbricating the third eyelid conjunctiva. In the newest technique for “cherry eye” replacement (Vet Ophth 2014; 17: 81-86), the conjunctiva is partially dissected from the bulbar surface of the prolapsed gland, and a 5-0 nylon suture is used to “anchor” the gland to the ventral rectus muscle. This requires a special instrument (Gass muscle hook, Sontec Instruments, item # 12-6910), but this technique has promise for leaving the third eyelid mobile with potentially less chance of re-prolapse in those dogs with lax periocular/adnexal tissues mentioned above. This technique can be seen on YouTube, check out “cherry eye replacement, canine”, https://www.youtube.com/watch?v=uBmCpekwpcc.

Surgery for Corneal Ulcerations
Spontaneous Chronic Corneal Epithelial Defect (SCCED)
Indolent ulcers, “Boxer ulcers”, refractory ulcers, and superficial erosion complex are all names to describe a condition seen in the canine species where the corneal epithelium is “loose” and repeatedly strips off, leaving an exposed underlying corneal stroma. Two hallmark clinical signs are seen in cases of SCCED: an epithelial defect only (no obvious stromal loss with biomicroscopic examination) and inability of the epithelium to adequately adhere to the underlying corneal stroma. Initially described in the Boxer breed in the 1960’s, this disorder may be seen in any breed. Most afflicted dogs are older, and there is usually no other obvious underlying ocular disease (KCS, exposure, poor blink, brachycephalic conformation, corneal edema, etc.) to explain the poor healing. Historically, dogs may or may not have a history of ocular trauma that initiates the disorder. Many dogs are painful (blepharospastic, epiphora), but some are not. Due to the lack of epithelial covering, the stroma in the area of epithelial void may appear grey/white due to faint corneal edema. When stained with fluorescein, a central area of stromal staining occurs, and the fluorescein may be seen to undermine the loose epithelium surrounding the “ulcer”.

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Manipulation of the corneal epithelium reveals that the epithelium is “loose” and poorly adherent to the stroma. This loose epithelium may be peeled back with a Q-tip to reveal an epithelial void many times larger than the original stain retention. Histologically, the anterior stromal layers are abnormal in this disorder. Absence of keratocytes and abnormal protein lamellae are frequently noted. Although the epithelium covers the void, the unhealthy stroma does not undergo remodeling with firm attachment of the stroma to the underlying epithelium. With chronicity, corneal neovascularization may occur (especially with Boxers), but many dogs heal once treated with no vessel ingrowth. With chronicity, the vivid staining of the stroma may take on a less vivid retention, indicating that the superficial stromal tissue is non-viable and less hydrophilic.

Therapy for SCCED involves removing the non-adherent epithelium and removing the abnormal anterior stroma as well. Vigorous debridement of abnormal exposed stroma with a dry Q-tip, needle (striate keratotomy or punctate keratotomy), or scalpel (superficial keratectomy) will get rid of the “dead” stroma and allow the normal deeper stroma to remodel and ultimately adhere to migrating epithelium. With a striate keratotomy, a 25-ga needle is used to LIGHTLY scarify the anterior stroma in a grid-like pattern. With practice, this may be done in an awake dog with topical anesthesia. The “scratches” should be 0.5 – 1 mm apart, and only deep enough to be visualized, no deeper. They should totally cover the area devoid of epithelium following Q-tip epithelial debridement. A punctate keratotomy is performed with a 20-ga needle and preferably a sedated or anesthetized patient (personal preference). Following epithelial debridement, the needle is held lightly perpendicular to the corneal surface. Pressure is placed on the cornea until the cornea indents. This usually equates to a quarter thickness or less puncture into the corneal stroma. Punctures should be placed no further than one mm apart, covering the entire debrided surface. Superficial keratectomy may be performed in an anesthetized patient using standard technique. Alternatively, a “rust remover tool” (looks like a Dremel tool, Algerbrush Corneal Rust Ring remover, aurorasurgical.com) may be used to mechanically remove superficial stroma instead of using a scalpel. Following surgical manipulation, many supportive therapies have been described. Topical application of extended wear soft contact lenses will help reduce shearing forces from lids on corneal surfaces and may enhance epithelial adherence. AccuView™ and other human lenses may be used (ask your optometrist for some “samples”. For large dogs, use an 9.0-9.6 mm base curve, for medium dogs, use an 8.6-8.8 base curve, and for small dogs use an 8.2-8.4 base curve). The smaller diameter (14.5 mm) human lenses will not totally cover the corneal surface, but may help with healing. It is important to place the lens under the third eyelid. If the lens stays on the cornea for 10 days, it will need to be removed at 10-14 days (canine corneas seem to need more oxygen than do human corneas). There are a number of veterinary companies who now make soft contact lenses (Acrivet™; D2 size most common dog, with D1 for smaller dogs and D4 for big dogs. D4 lens = C3 lens, for large eyed cats), but they are pricey (~$46/lens) compared to freebie human lenses. Topical antibiotics are needed to prevent superficial infection until the epithelium is intact. Many prefer drops to ointments; I prefer not to use aminoglycoside-containing antibiotics (aminoglycosides are slightly epithelial toxic). Anti-inflammatories (oral NSAID’s and topical atropine) are indicated only if pain and anterior uveitis are present. Many use topical application of canine serum. The epithelial growth factor in serum will enhance epithelial growth and migration. Since proteolytic enzyme corneal degradation is not a major issue in these cases, use of anti-proteolytic agents such as acetylcysteine is not usually necessary. In man, oral tetracycline has been shown to enhance healing of these erosions by minimizing activity of matrixmetalloproteinases present in the tear film (that are present at higher levels in these eyes than in normal eyes); many ophthalmologists use oral doxycycline or topical tetracycline ointment in these canine patients. Many cases will heal within 10 days with no neovascular response and minimal scarring. Boxers routinely heal with a notable vascular response. If the erosion is not totally healed in 10 days, reassess the cornea. If there are areas of non-adherent epithelium where surgical manipulation has not been performed, consider debridement and scarification. If the epithelium is not totally adherent over a scarified area, wait a few more days to see if it will bind down versus repeating total debridement. Epithelial bonding is usually slower in brachycephalic dogs compared to normal dogs. 

Proteolytic enzyme, “melting” ulcers
Veterinary practitioners are commonly presented with corneal ulcerations that progress rapidly, resulting in descemetocele formation or corneal rupture. Brachycephalic/prominent eyed breeds of dogs are certainly over represented as well as dogs with KCS. Some of these cases have a gelatinous, “hot wax” look; some of these cases appear as if someone had used a trephine to carve a deep void in the cornea (“well holes”). There are many causes for these rapidly developing corneal ulcers. A thorough understanding of the processes involved in corneal wound healing is essential to understand the different treatments used to treat these cases.

Proteolytic enzymes (“collagenases”) are universally accepted as the cause for these ulcers. Proteolytic enzymes may be bacterial in origin (Pseudomonas spp. are commonly accepted as being bacteria with excessive proteolytic enzyme producing capability, but other gram negative bacteria and even certain gram positive bacteria (Strep spp.) can produce large amounts of proteolytic enzymes). Dying neutrophils drawn to an area of corneal stromal injury may release their lysosomal enzymes, causing further corneal necrosis. “Self digesting” proteolytic enzymes (matrixmetalloproteinases, MMP-2 and MMP-9, especially) found within the corneal epithelial cells, the stromal fibrils, and the keratocytes may override healing MMP, resulting in a net necrosis. All these enzymes may have additional impact if there is decreased tear quantity or quality (if the degradative enzymes are not being rinsed away due to a lack of tears or poor distribution of tears due to poor blink, the cornea “stews in its own juices”), resulting in corneal “melting” in even a sterile environment. Lastly, decreased corneal sensitivity in brachycephalics and other dogs with CN V disorders (so called “neurotropic keratitis” in human stroke victims) may result in a lack of neuropeptide release that normally lead to activation of the healing process or inhibition of the destructive process.

Therapy for these “melting ulcers” should be swift and intensive. Firstly, adequate rinsing of proteolytic enzymes from the cornea is essential. If the dog has KCS or incomplete blink, using topical medications as often as q15min will help dilute these proteolytic enzymes. Ointments that trap proteolytic enzymes are very counterproductive. If a massive accumulation of necrotic goo is on the ulcer surface, gently remove the exudates with a moistened Q-tip (some like to use 1% Betadine), a forceps, or even a fine scissor is indicated. Drugs that inhibit proteolytic enzymes include topical acetylcysteine, topical NaEDTA solutions, oral tetracycline, and topical canine serum. Acetylcysteine inhibits binding of proteolytic enzymes to corneal stromal tissue, as does NaEDTA. Acetylcysteine may be made up in solution with artificial tears and antibiotic (a common “ulcer mix” used by many includes 15 ml saline based artificial tears with 2 ml of an antibiotic (injectable 100mg/ml gentamicin or chloramphenicol) plus 2-4 ml of 20% acetylcysteine, refrigeration recommended). Injecting 1-4 ml of saline into a large purple-topped blood collection tube will make an appropriate NaEDTA solution. These drugs may be alternated every 15 minutes in an attempt to reverse the proteolytic enzyme degradation. Serum contains not only epithelial growth factor and fibronectin, but also alpha macroglobulin from clumping platelets. For years, we have said that serum is preferred over plasma, but a recent paper (VetOphth 18(3): 229-233, May2015) showed plasma to be as effective as serum in a research environment. Both serum and tetracycline have been shown to negate the digestive enzyme activities of MMP-2 and MMP-9 in human and equine tears. Certain other antimicrobials have been shown to have anti-proteolytic enzyme activity as well. The fluoroquinolone antibiotics (e.g., ciprofloxacin, Ciloxin™) have been shown in human experiments to negate proteolytic enzyme activity. All these medications may be used in cases of “melting” ulcers in an attempt to reverse the destructive corneal enzyme activity and allow for normal corneal healing.

In the case of extensive necrosis (very deep corneal wound or descemetocele), surgical intervention is necessary to prevent corneal perforation with potential loss of the eye. Third eyelid flaps are almost NEVER indicated in canine cases like these. Although they may support a weak cornea, they inhibit distribution of medication to the corneal surface, hold proteolytic enzymes in place on the cornea, and inhibit observation of the eye. That being said, there occasionally is indication to use a third eyelid flap to protect a less damaged cornea and help distribute tear in cases of palpebral nerve paralysis and inability to blink.

 Conjunctival grafts/flaps are used to enhance corneal healing in the face of “melting ulcers”, deep corneal ulcers, or descemetoceles. By transposing vascular, epithelialized tissue to the ulcer bed,
immediate healing of the wound may take place. In cases of septic corneal wounds and gelatinous necrotic cornea, conjunctival grafts are more appropriate than corneal advancements (corneal-conjunctival transposition) or transplants. Numerous types of conjunctival grafts are described in surgery texts. Case selection and surgeon preference will determine if a 180 degree “hood” flap, a “bridge” flap, or a rotating pedicle “finger” flap is best.

One of the simplest conjunctival flaps to raise is a dorsal 180° “hood flap”. I prefer to do all conjunctival and corneal surgery “over the top”. Following placement of a Barraquer lid speculum, I like to place a 6-0 silk stay suture at the limbus to enhance manipulation of the globe. I usually place a stay suture at 12 o’clock, but some place stay sutures at 3 and 9 o’clock. The conjunctiva is lifted at the 12 o’clock limbus, and a snip incision is made with a Steven’s tenotomy scissor. The tips of the scissors are passed into the subconjunctival space, and the conjunctiva is bluntly dissected away from the underlying avascular Tenon’s capsule. This is a situation where a very thin conjunctival graft is essential. If you can see your scissor through the conjunctiva, you are thin enough and in the correct tissue plane. The conjunctiva is dissected initially through the small hole, and then the conjunctiva is cut along the limbus. Cutting along the limbus prior to dissection is a good way to get into a deep tissue plane and undermine the avascular Tenon’s capsule. Once conjunctiva is dissected around the dorsal 180°, the conjunctival flap should be able to be pulled across the corneal surface. If the flap is “too thick”, and contains Tenon’s capsule (white, shiny, non-stretching avascular tissue), an assistant can raise the conjunctiva and the surgeon can peel/dissect the Tenon’s capsule from the overlying conjunctiva. Care must be taken to not “buttonhole” the conjunctiva. Once the conjunctiva is free and mobile, it is sutured medially and laterally to the limbus with 7-0 or 8-0 Vicryl™ such that there is little tension required to completely pull the flap over the ulcer. Next the conjunctiva is sutured to the cornea ventral to the ulcer so the ulcer is completely covered by the flap. Pass the needle through the conjunctiva, into the cornea (1/2 thickness or more) and then back out the conjunctiva so that the suture tract is parallel to the leading edge of the flap. 3-4 corneal sutures should hold the flap in place adequately. Remove the stay suture, and perform a partial temporary tarsorrhaphy (2 sutures over rubber band stents). Continue topical application of antibiotic and systemic antibiotic as well as anti-inflammatory drugs for up to 2 weeks. Usually the temporary tarsorrhaphy sutures can be removed in 7-10 days. Without the temporary tarsorrhaphy, the conjunctival graft may swell, the lids may not close, and the graft may dry out, desiccate, or dehisce.

If the ulceration is dead center (usually is), it may be difficult to stretch the conjunctiva over the ulcer, especially in a large corneal surface dog like a brachycephalic breed (or a cat). A releasing incision (parallel to the incision of the graft from the limbus) with the graft still attached to the globe medially and laterally makes a “horizontal bridge graft” out of a “hood graft”. The graft must now be sutured on both sides to hold it in place (both in the cornea and at the medial and lateral limbus). Horizontal bridge grafts are relatively easy to raise, but the up and down motion of the lids during eyelid closure has a tendency to roll the edges of the graft and can lead to dehiscence. If a bridge graft is anticipated, a “vertical bridge graft” (my favorite conjunctival graft) would be better in that the blinking motion does not tend to roll the graft edges, as is the case with a horizontal bridge graft. Because of the third eyelid, vertical bridge grafts are best raised from the lateral bulbar conjunctiva. I usually place 6-0 silk stay sutures at 6 and 12 o’clock to manipulate the globe. When dissecting the conjunctiva from the lateral globe, rotating the globe nasally tends to flatten out the lateral conjunctiva and make the dissection of a thin graft easier. As was the case with the horizontal bridge graft, the conjunctiva has to be sutured to cornea and sclera on both sides of the graft.

The quickest graft to raise in the hands of an experienced surgeon is a “rotating pedicle graft”. Usually raised from the lateral bulbar conjunctiva like a vertical bridge graft, this graft is only attached at one end, with the flap being a “finger” or “pedicle” that must be adequately sutured into the ulcer bed. With proper debridement of necrotic corneal tissue, this flap may be sutured into the cornea on 3 sides with the “base” typically being at 12 o’clock. Since grafts tend to contract back towards their attachment to the limbus, it is imperative that this graft be sutured into solid cornea or it can dehisce as the graft heals and contracts. As was the case with the other grafts, a protective temporary tarsorrhaphy should be placed for the first 7-10 days post-op to minimize the chance for graft drying and dehiscence.
Once a graft has healed into the corneal ulcer site, and the vascularization has risen to its fullest splendor and regressed (usually about 6 weeks post-op), the unattached conjunctiva can be cut free from the healed ulcer site. Many mild mannered dogs can have this done following application of topical anesthetic and 10% phenylephrine or 1:10,000 epinephrine diluted in saline to help maintain hemostasis. Using a tissue forceps, the pedicle of tissue extending to the healed site is lifted and one blade of a Steven’s tenotomy scissor is slipped beneath the pedicle and the pedicle is cut free from the healed ulcer site. Topical cyclosporine (Optimmune™) will help reduce the corneal vascularization and will help with corneal remodeling without fear of weakening the repair as can be the case with topical steroid administration.

**Corneal lacerations**

Corneal lacerations/perforations can occur secondary to trauma (both sharp and blunt) and secondary to rupture of deep ulcers. Cat toenails and teeth are common causes of corneal lacerations secondary to fighting. In field dogs, puncture wounds from thorns and other objects are more common than for the “couch potato” housedog. There are a number of factors concerning lacerations/perforations that will determine the prognosis for saving the globe and/or salvaging vision. Superficial “shearing” type lacerations that do not enter the anterior chamber carry a fairly good prognosis if they do not get infected. It is usually best to trim some of the non-viable loose flap of tissue unless extremely deep or perforating into the anterior chamber. If deep and not grossly contaminated, direct suturing of the flap to the underlying stroma should be attempted. Exposed corneal stroma should be treated as if a corneal ulcer. If the void following cutting the flap is extremely deep or perforating, the surgeon will need to do a conjunctival graft for support and immediate vascularization. Perforated infected ulcers and descemetomeceles carry a poorer prognosis than clean lacerations due to risk of endophthalmitis (infectious organisms within the eye itself from the corneal disease) and due to the usually necrotic tissue surrounding the perforation that will not hold sutures for closure. Small, clean lacerations made by sharp, basically “sterile” objects carry a higher success rate than wounds made by herbaceous materials or “contaminated” objects (cat toe nails). “Sealed” wounds do better than wounds that yield a flaccid globe (less likelihood of intraocular sepsis or retinal detachment). Large blunt trauma “blow outs” that expel tissue carry a very poor prognosis (increased incidence of intraocular damage with resulting glaucoma or phthisis bulbi, retinal detachment, etc.). Scleral rupture/laceration with ciliary body and/or choroidal prolapse carries a poor prognosis (high incidence of retinal detachment and/or phthisis bulbi). Severe, total hyphema usually carries a poor prognosis, as does severe, continuous hyphema.

Therapy for corneal lacerations is surgical repair as soon as the patient is stable enough for anesthesia. Pre-operative therapy may include systemic NSAID’s, topical antibiotics (try to stay with drops, not ointments), topical antifungals if injury is known to be caused by herbaceous material, topical atropine, systemic antibiotics, and protection of the globe (E-collar to prevent self-trauma). If the patient is fractious, and therapy could result in worsening of the situation (further expulsion of ocular contents), do not try to treat topically and make matters worse. Prepping of the surgical site should be with scissors coated with K-Y jelly (not clippers that make thousands of tiny pieces of hair) and copious flushing with saline and/or VERY dilute povidone iodine in saline (final concentration 0.1-0.25 %). Be careful not to express further intraocular contents with aggressive prepping. If the iris is prolapsed, is probably better to amputate prolapsed portion than to replace contaminated tissue back into anterior chamber. To reduce hemorrhage, use microcautery to amputate or crush with fine scissors (Steven’s tenotomy) and topical application of 1:10,000 concentration of epinephrine (diluted with PSS or LRS). Retract the prolapsed iris to a point of normal iris, cut (or cauterize, be careful to not burn cornea) at corneal surface, and allow the normal iris to retract into the anterior chamber. If the ciliary body or choroid has prolapsed through the sclera, unless grossly contaminated, do not get too aggressive with excision, just replace. Prior to complete corneal closure, gently irrigate anterior chamber free of blood/fibrin clots with LRS or saline using a 25 or 27-ga intraocular cannula. Use of 1:10,000 diluted epinephrine will help to reduce uveal hemorrhage and dilate the pupil. All uveal tissue should be freed from the corneal wound margins prior to closure (iris spatula or small gauge irrigating cannula). Suture cornea/sclera with 7-0 or 8-0 Vicryl, simple interrupted pattern (halve the wound, quarter it, then fill it in). Sutures should be placed 1-2 mm apart, 4-5 throws per
knot, cut suture right at the knot. Suture bites should be deep, almost full thickness (in fact, it is better to err on the side of too deep than too superficial and have the closure dehisce in 24 hours). Re-inflate anterior chamber through wound with blunt tipped 25 or 27-ga cannula or through a limbal stab with 27-ga needle to normotension with LRS or saline, +/- air (air can help retropulse iris from cornea, but can also increase contact between posterior iris and lens leading to post-operative posterior synechia. Na hyaluronate (Adequan™) can be used to maintain an anterior chamber and can be safely left in anterior chamber.). Temporary tarsorrhaphies, third eyelid flaps, and conjunctival grafts may be used to support/aid healing (hood, bridge, or pedicle, depends on where wound is). Post-operative systemic and topical antibiotics, topical atropine, +/- topical antifungals, and systemic NSAID’s are warranted. The surgeon can expect lots of anterior uveitis immediately post-operatively, and continued anterior uveitis is frequently seen until the corneal wound has vascularized and is healing well.

Lens rupture with secondary phacoclastic uveitis may occur in animals that have experienced a puncture wound with laceration of the lens capsule. Lens protein is “walled off” from the developing immune system early in embryogenesis, so release of this “foreign” protein into the eye causes intraocular inflammation (this is much more severe with lens protein that has further been altered by cataractagenesis as is the case with diabetic cataract lens capsule ruptures). Large lens lacerations with gelatinous white material protruding through the pupil carry a very poor long term prognosis due to severe lens protein induced uveitis (“phacoanaphylactic or phacoclastic uveitis”) as well as potential for sepsis from the original cat claw that caused the laceration.

For years, immediate removal of the lens was considered the gold standard treatment of choice for these cases; otherwise, intractable uveitis can lead to secondary glaucoma, retinal detachments, and/or eventual phthisis bulbi. YEARS later, lens ruptures in cats (especially those that have undergone phthisis bulbi following injury) can lead to a type of intraocular tumor seen only in the cat (undifferentiated sarcoma). For this reason, most veterinary ophthalmologists recommend enucleation of phthisical eyes in cats, especially if the cause is suspected to be due to a previous puncture wound, etc.

In a situation where surgical intervention is not possible, medical therapy may include topical antimicrobial therapy, topical parasympatholytic agents, topical NSAIDs (followed by topical steroids after the corneal wound is healed), systemic NSAIDs or steroids, and weeks of systemic antibiotics. Repair of the corneal wound should be performed if there is uveal prolapse or a leaking anterior chamber. A relatively recent article (Vet Ophth, 15(6): 355-368, 2012) concerning a retrospective study of lens ruptures in dogs and cats revealed that animals undergoing medical therapy alone had a better long term prognosis than animals that had corneal repair and lens removal or corneal repair alone. One must take into consideration that case selection (small, sealed corneal wounds with small lens capsule ruptures were treated mostly medically) was important in the outcome of this series of retrospectively analyzed cases.