



Review Article

Update on surgical cosmetic solutions in equine ophthalmology

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ABSTRACT

Following eye removal surgery, ocular cosmetic solutions exist for the equine patient. The objective of this review is to summarize the current best evidence on equine ophthalmic cosmetic solutions. A literature review of ophthalmic cosmetic solutions in horses was conducted. Four cosmetic solutions are described. Cosmetic outcome, return to work, owner satisfaction, complication rates, implant choice and future perspectives are discussed under the light of most recent publications. Seventeen peer-reviewed articles were selected: five retrospective studies, four case series, five case reports and three narrative reviews. Additionally, two congress proceedings were included. Recent publications identify intrascleral prosthesis and intraorbital implants adjoined to a corneoscleral shell as cosmetically superior. The orbital meshwork implant requires improvement to be cosmetically acceptable. Return to work is deemed feasible and standing sedation is an option for orbital implant placement beneath sutured eyelids. 3D printing creates new possibilities for implant development.

1. Introduction

Trauma of the eye, uveitis, glaucoma, corneal ulcers, non-traumatic keratitis, and neoplasia are common conditions in the horse [1,2] and can cause irreversible damage, chronic pain, or blindness [2–5]. Eye removal by enucleation, evisceration, or exenteration, may be necessary to improve the quality of life of the horse [4,6–8]. Enucleation is the excision of the entire globe, nictating membrane and conjunctiva. The approach can be either transpalpebral or transconjunctival [9]. Evisceration consists of the removal of the intraocular contents (aqueous and vitreous humours, uvea, lens, retina) and preservation of the corneoscleral layer [5]. Exenteration refers to the removal of the entire orbital content and is usually performed in case of severe orbital neoplasia or infection. After these last resort procedures, the cosmetic appearance of the animal is usually deeply impaired, mainly because of the sunken orbit or the unsightly corneal pigmentation. Although non-life-threatening, this can impact both the owner's psychological perception of their animal and the horse's economic value [2,3]. Various ophthalmic cosmetic solutions have been proposed such as intraocular prosthesis, intraorbital implants beneath sutured eyelids or adjoined to a corneoscleral shell, and orbital suture meshwork implants [2,4,10]. Since a review by Michau and Gilger in 2004, several scientific papers on the subject have been published but a recent review of the literature is

lacking [4]. The aim of this article is to review and illustrate surgical cosmetic solutions after eye removal surgery. Scientific publications selected for the present review are summarized in the Appendix. Cosmesis, return to work, owner satisfaction, complication rates, use of standing sedation, choice of implant size and material, and future perspectives are addressed using recent best evidence on the subject.

2. Literature search strategy

A literature search was performed in the PubMed, Google Scholar and Cabi Abstracts databases. [Ocular implant], [orbital implant], [ocular prosthesis], [equine ophthalmology] and [corneoscleral shell] were used as keywords. Articles published prior to 1980 were excluded. Publication language was not restricted. Included publications had to discuss at least one *in-vivo* cosmetic solution in equine ophthalmology (intraocular prosthesis, orbital implant, corneoscleral shell, orbital suture meshwork implant) following eye removal surgery. Seventeen peer-reviewed articles were identified as relevant: five retrospective studies, four case series, five case reports and three narrative reviews. Additionally, a retrospective study and a review published as congress proceedings were included in the present review. Salient features of papers are summarized in the Appendix.

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3. Results

3.1. Intraocular prosthesis

Placement of an intraocular prosthesis, also called intrascleral prosthesis, can be considered following evisceration (Fig. 1-B) [4, 10–12]. The eye removal surgery and prosthesis implantation are performed in one surgical episode to avoid corneoscleral shrinkage as well as limit costs and anesthetic risks [6,7]. The technique was described in four single case reports [13–16], one case series [11], one retrospective studies [17] and more recently, in 2014, in another descriptive study in 13 horses [5]. It has also been described in textbooks and reviews [2,4, 6–8]. Main indications for this procedure are chronic uveitis, glaucoma and early phthisis bulbi. Endophthalmitis, panophthalmitis, intraocular neoplasia, severe scleritis or keratitis, and severe end-stage atrophy are reported to be contraindications [2,4–8,10,13]. Eyes with corneal or scleral lacerations are also considered not suitable for surgical intraocular prosthesis placement [5,8]. Ideally patients should have healthy sclera and cornea, a well-functioning tear film, and normal eyelid function [4]. Surgical steps are illustrated in Fig. 2. Technical details concerning sutures and prosthesis as reported in the scientific literature are presented in Table 1. The surgical procedure starts by a lateral canthotomy. Retention stitches can be placed in the limbal sclera to maintain the globe in position [5]. An incision of the bulbar conjunctiva and Tenon's capsule is performed on the dorsal aspect of the globe, 4 to 6 mm from the limbus. The sclera is incised full thickness parallel to and posteriorly to the limbus for approximately 3 cm. The entire ocular content (uvea, retina, aqueous and vitreous humours, lens) is separated from the corneoscleral shell with a lens loop and extracted. Scraping of the corneal endothelium is avoided [2,4,7,8]. Flushing of the shell is performed using saline solution. The intraocular prosthesis is placed within the corneoscleral shell, either manually or with an introducer [4, 8]. Insertion should be easy, with the prosthesis not touching the eyelids or conjunctiva. The apposition of the scleral margins should be easy when the size of the prosthesis is adequate [7,8]. The sclera and conjunctiva are sutured, followed by the conjunctiva. The lateral canthotomy is closed. Temporary tarsorrhaphy for a 1-to-4-week period can be considered to protect the cornea and to limit wound dehiscence and implant extrusion [4,7,11]. The healing process lasts 6 to 8 weeks [2, 13]. During this period, several changes can be observed such as post-operative hematoma visible through the cornea, a temporary interstitial vascular keratitis, periocular soft tissue swelling, and a mild mucoid ocular discharge [13,15]. The cornea appears diffusely edematous [14]. Inflammation, neovascularization and impairment of the physiological corneal metabolism induce a modified appearance of the corneoscleral shell. Under TGF β -influenced pathways, keratocytes differentiate into corneal fibroblasts, and fibrocytes are drawn from the limbal vasculature. Both cell types differentiate into myofibroblasts and produce a structurally and chemically disordered extracellular matrix associated

with degenerative stromal fibrosis. The duration of the remodeling process depends on the species [18]. Toth and al. report a three-month period for the remodeling of the cornea into connective tissue in the horse after evisceration and prosthesis placement [5]. Owners should be warned about these changes [4,6,7]. The eyelids and globe should retain normal motor function [15]. The main postoperative complications appear to be corneal ulceration and keratitis [5]. Preoperative damage to the cornea or sclera increases risks for post-operative complications [4–7]. Other reported postoperative complications include persistent/increased ocular discharge, surgical site dehiscence, septic or powder-induced endophthalmitis, severe periocular swelling and prosthesis extrusion [8]. Poor cosmesis can also happen due to corneal opacification, vascularization, or scarring [5].

3.2. Orbital implant with suture of the eyelids

An orbital implant can be placed within the orbital cavity, immediately after enucleation, and the eyelids are sutured (Fig. 1-D). The procedure was reported in two case series of 28 and 11 horses, two retrospective studies and a congress proceeding [11,19,21–23]. More recently, in 2017, a retrospective study reported the use of intraorbital implants with sutured eyelids in 49 horses [9] and discussed surgical site infection risk factors, long-term cosmesis and return to work. In 2021, the procedure was described in 20 cases under standing sedation [20]. Reported indications for this cosmetic solution include severe trauma, corneal diseases, glaucoma, neoplasia, chronic inflammation unresponsive to any other treatment, uncontrollable endophthalmitis or panophthalmitis, congenital diseases such as microphthalmia, and phthisis bulbi. Neoplasia or infection of the orbit should preclude use of this technique [2,4,6,8,9,20]. The procedures for transconjunctival and transpalpebral enucleations have been thoroughly described elsewhere [2,4,6–8]. The orbital implant is placed within the orbital cavity [8]. Closure of the anterior periorbital fascia, eyelid subcutaneous tissue and eyelid skin is then performed [7]. For both techniques, precise excision of the meibomian glands before closure is important to avoid post-operative secretions and cyst formation [4,6–8,20]. Sutures may be attached to the periorbital, over the orbital implant, to secure it from unwanted movement [7]. Intraorbital hematoma and subsequent infection as well as epistaxis and swelling can occur postoperatively [19, 20]. Other reported complications include globe rupture during surgery, orbital cyst formation, contralateral blindness, implant extrusion and poor cosmesis due to unwanted movement of the implant [2,4,19]. Surgical steps are described in Fig. 3. Technical details (suture and implant) are presented in Table 2.

3.3. Orbital implant associated with an ocular prosthesis

Orbital implants can be associated with a cosmetic ocular prosthesis, also called a corneoscleral shell or conformer (Fig. 1-C). The prosthesis is

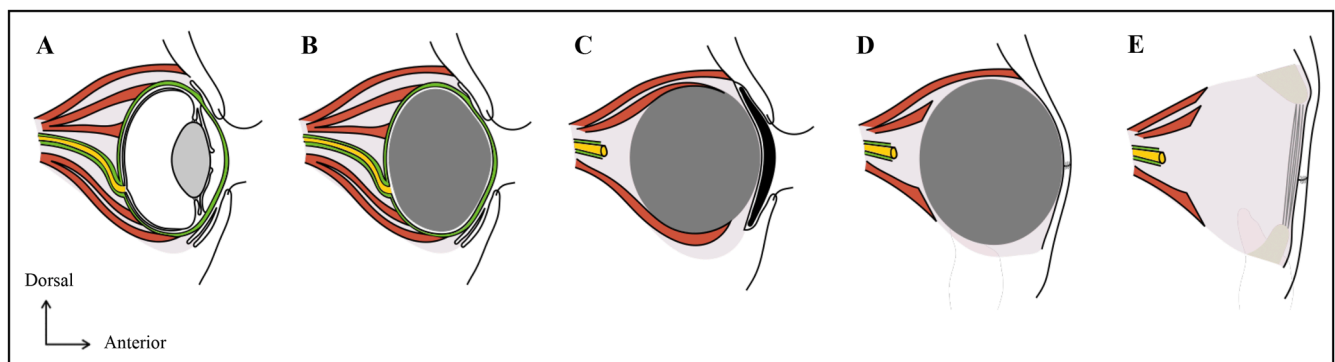


Fig. 1. Ophthalmic cosmetic solutions. (A) Normal eye, (B) Intraocular prosthesis, (C) Orbital implant associated with a corneoscleral shell, (D) Orbital implant with sutured eyelids, (E) Orbital suture meshwork implant with sutured eyelids.

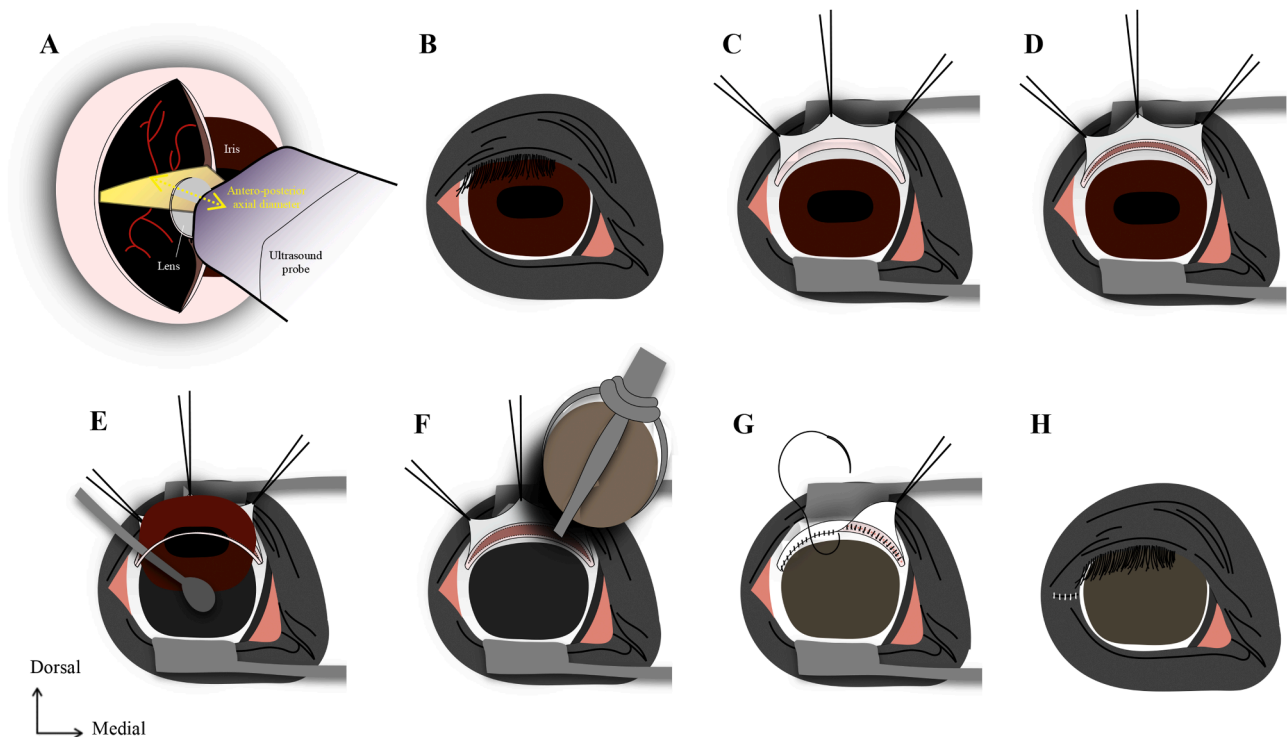


Fig. 2. Evisceration procedure and intrascleral prosthesis placement [4,6–8,10]. (A) Ultrasonographic measurements of the anteroposterior diameter for implant diameter choice. (B) Lateral canthotomy. (C) Arcuate incision of the bulbar conjunctiva and Tenon’s capsule 4–6 mm from the limbus and exposure of the sclera. (D) Incision of the sclera. (E) Separation and protraction of ocular contents from the corneoscleral shell with a lens loop, followed by flushing of the shell with sterile saline. (F) Insertion of the intraocular implant within the corneoscleral shell. (G) Suture of the sclera and conjunctiva. (H) Suture of the lateral canthotomy.

Table 1
Suture and prosthesis details for the intrascleral prosthesis.

		Sclera	Conjunctiva	Lateral canthotomy
SUTURE [4–8, 10,11, 13–15]	Type	Absorbable sutures (Polyglactin 910, Polyglyconate)	Nonabsorbable sutures (Nylon, Silk)	
	Size	4-0 – 6-0	2-0 – 4-0	
	Pattern	Simple interrupted or continuous pattern	Simple continuous pattern	Simple interrupted pattern
PROSTHESIS	Material	Medical-grade silicone (Eickemeyer eye implant, Eickemeyer KG, Tuttlingen, Germany) [5]		
	Size	Estimation by measuring the normal contralateral corneal diameter with calipers and adding 1–2mm to that measure [6,7] or by assessing the antero-posterior axial diameter by ultrasonography [4] From 28–33mm [5] to 34–44 mm in adult horses [4,6–8,10,11,13–15]		

fitted between the conjunctival stump and the functional eyelids. This technique was first described in a horse in 2003 [24]. The use of the procedure in eight horses was mentioned by Michau and Gilger in 2004 [4]. Indications and contraindications are mainly the same as those for orbital implants with sutured eyelids. Preservation of eyelid function and anatomical integrity of orbital structures such as conjunctival fornices, extraocular muscles and orbital soft tissue is reported to be primordial for the success of this cosmetic solution [4]. Horses presenting with abnormal fornices and non-functional eyelids should not be considered for this procedure. Surgical technique is illustrated in Fig. 4. Technical details (suture and implant) are presented in Table 3. Twenty-four hours prior to the beginning of the procedure, a normal eye from a euthanized horse is enucleated. The enucleated eye is cleaned of its cornea, extraocular muscle insertions and intraocular content, leaving only the donor scleral shell. Four full-thickness openings (medial,

lateral, dorsal and ventral) are created on the posterior aspect of the donor sclera, 1 cm anteriorly to the posterior pole. It is then placed in 100% ethanol for a day. One hour prior to surgery, it must be immersed in warm sterile saline [4]. Immediately before the procedure, the sterilized selected orbital implant is inserted within the prepared donor sclera [4]. The donor sclera aims to anchor the orbital implant to the recti muscles and limit abrasive contact between the orbital soft tissue and the hydroxyapatite orbital implant. A modified transconjunctival enucleation is then performed. Contrary to the conventional technique, extraocular muscles are isolated and identified with sutures before being transected near their scleral insertions. The remaining stumps will be used for orbital implant fixation and soft tissue coverage [4,24]. Transection of the retractor bulbi muscle, optic nerve and vasculature is then performed. Once the implant wrapped in donor sclera is placed within the orbital cavity, recti muscles are passed through the four scleral openings and anchored to the implant [4,24]. The oblique muscles are sutured onto the donor sclera, in their corresponding anatomical locations. Orbital fascia, Tenon’s capsule and conjunctiva are sutured separately and successively over the implant. After suture of the bulbar conjunctiva, a temporary transparent orbital conformer, manufactured by an ocularist, is placed under the eyelids. This aims to prevent eyelid contraction and to protect the surgical site [4]. A temporary tarsorrhaphy can be considered and should be removed after 3 days once the swelling has subsided. The conformer is then removed and cleaned with sterile saline solution daily. The mean recovery period ranges from 3 to 5 months and includes several ophthalmologist and ocularist visits for check-ups and final cosmetic ocular prosthesis fitting [4,24]. Complications for this procedure include implant migration and/or extrusion, infection and enophthalmos. Poor cosmetic outcome can also appear due to lower eyelid ptosis and contraction of the conjunctival fornices [4].

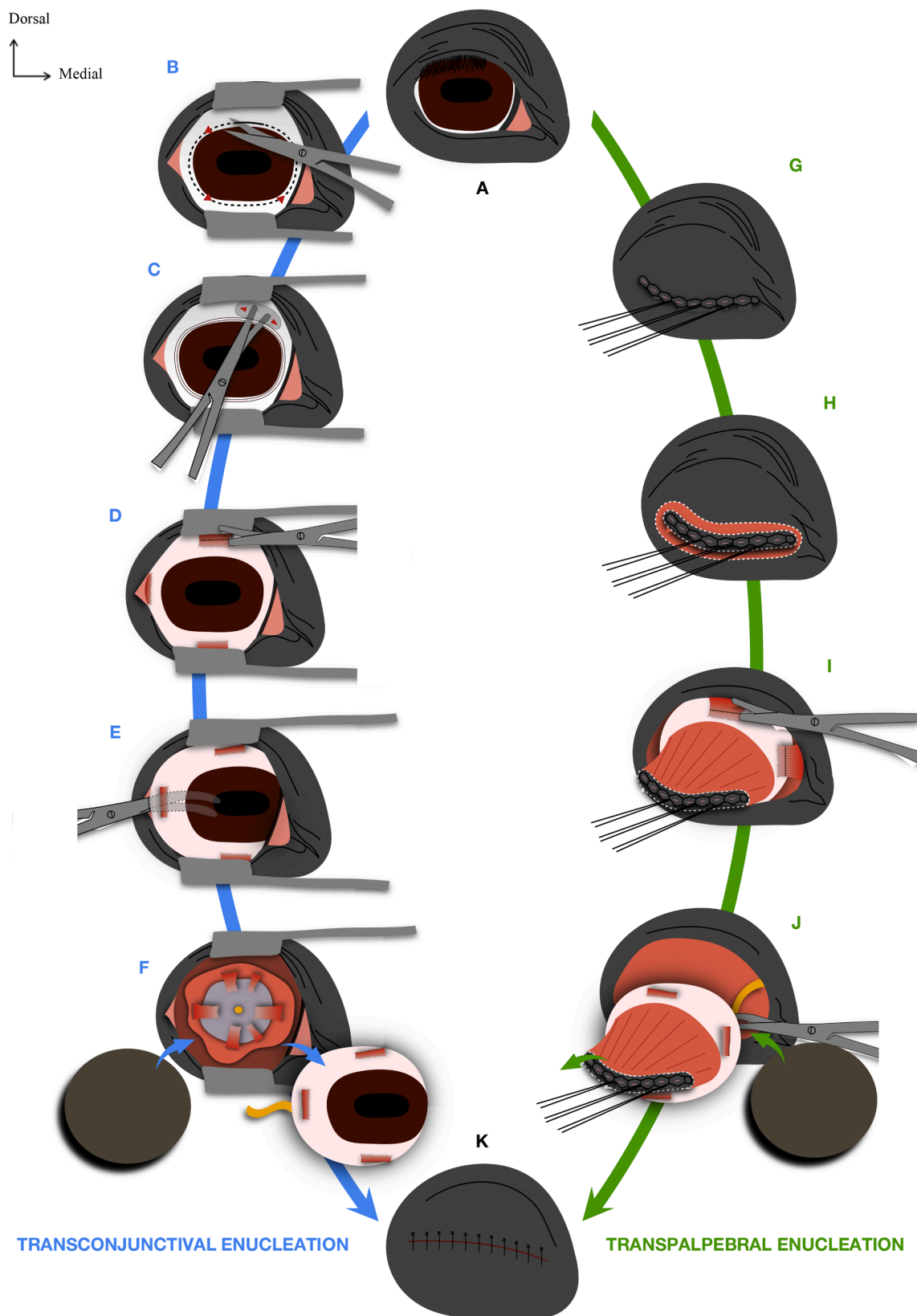


Fig. 3. Transconjunctival and transpalpebral enucleation with orbital implant placement [4,7–9,19,20]. Transconjunctival approach: (B) 360° conjunctival and Tenon's capsule peritomy around the limbus. (C) Blunt dissection between the sclera and Tenon's capsule. (D) Identification and transection of the extraocular muscles, which are left to retract posteriorly. (E) Retractor bulbi muscle, optic nerve and vasculature transection. (F) Globe extraction and nictating membrane excision followed by orbital implant placement within the orbital cavity. The eyelids' margins are then excised. Transpalpebral approach: (G) Temporary eyelid margins apposition. (H) Full-thickness incision 5 to 7 mm from the eyelids' margins, extended to the periorbita. (I) Extraocular muscles resection. (J) Retractor bulbi muscle, optic nerve and vasculature transection. The globe is extracted "en bloc" and the orbital implant is placed within the orbital cavity. (K) Anterior periorbital fascia, eyelid subcutaneous tissue and eyelid skin suture.

Table 2
Suture and implant details for orbital implant with sutured eyelids.

		Periorbital fascia	Palpebral subcutaneous tissue	Palpebral skin	Palpebral fissure
SUTURE [2,4,6,8,9,11,20]	Type	Nonabsorbable sutures (Polypropylene)	Absorbable sutures (Polyglactin 910, Poliglecaprone 25)	Nonabsorbable sutures (Polypropylene, Nylon)	Nonabsorbable sutures
	Diameter	2-0 – 4-0			2-0
	Pattern	Simple interrupted or continuous pattern	Simple continuous or intradermal pattern	Perforating simple interrupted, cruciate or continuous pattern	Continuous pattern
IMPLANT	Material	Medical-grade silicone (Jardor Eye Prosthetics Inc, Southfield, Mich) [4] Polymethyl methacrylate (PMMA) (Storz Instrument Company, St Louis, MO) [8]			
	Size	Subjective choice of implant diameter by successively placing implants of different sizes into the orbit Selection of largest one that can fit without undue tension, dependent on the horse's size and amount of periorbital swelling [9,19,20] 30-47 mm in the adult horse [11,19,20]			

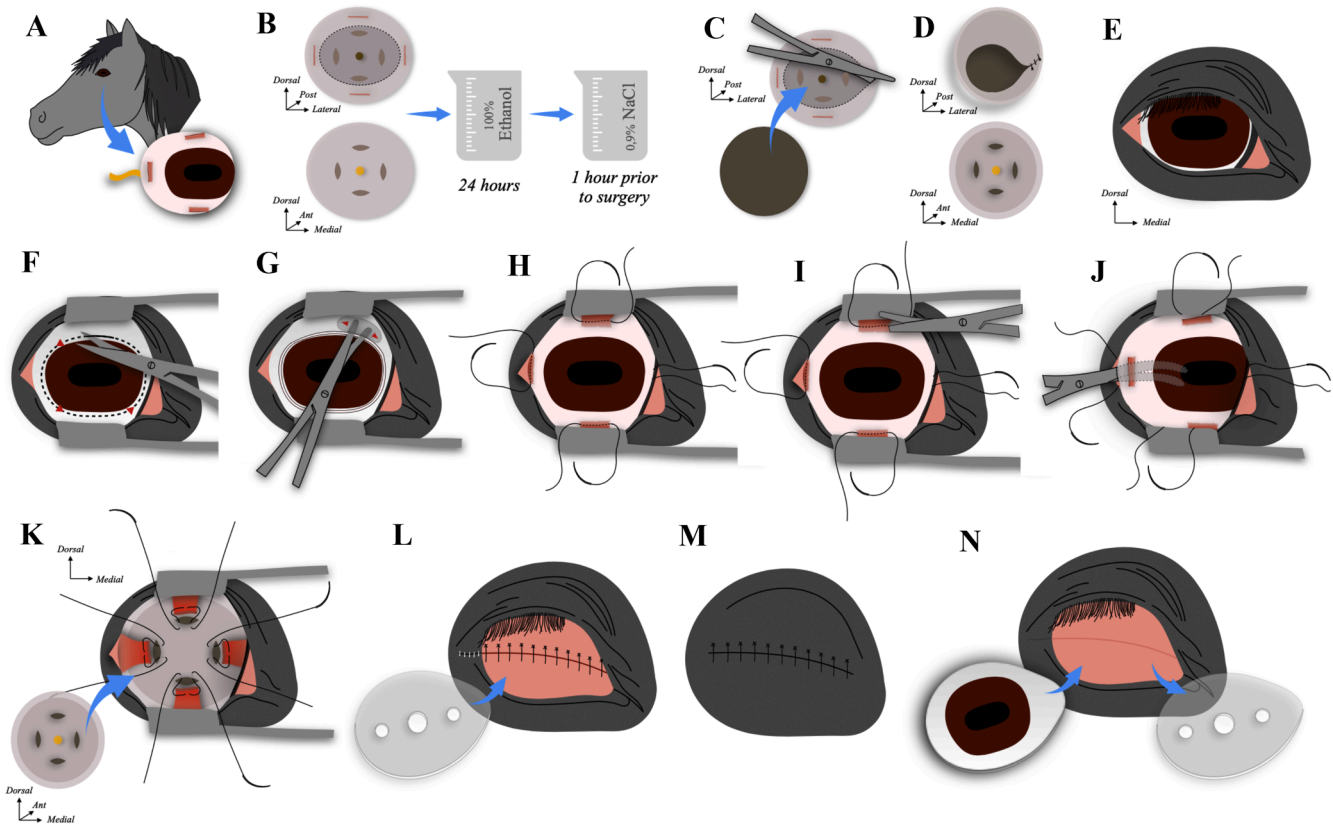


Fig. 4. Modified transconjunctival enucleation and orbital implant placement in conjunction to an ocular prosthesis [7,9,21]. (A) Enucleation of a euthanized horse for donor sclera sampling. (B) Donor sclera preparation: removal of cornea, muscle insertions and intraocular content followed by soaking in 100% ethanol for 24 h and soaking in sterile saline 1 h prior to surgery. (C) Placement of sterilized orbital implant within the donor sclera. As illustrated, a releasing incision can be performed to facilitate the insertion. The donor sclera is closed around the implant. (D) Releasing incision closure in a simple continuous pattern and creation of 4 full-thickness openings on the posterior aspect of the donor sclera, 1 cm anterior to the posterior pole. (E) Lateral canthotomy. (F) 360° conjunctival and Tenon's capsule peritomy at the limbus. (G) Blunt dissection between the sclera and Tenon's capsule. (H) Isolation of the extraocular muscles and identification of their insertion tendons with sutures. (I) Extraocular muscles transection. (J) Retractor bulbi transection and optic nerve transection. (K) Placement of the orbital implant wrapped in donor sclera within the orbital cavity and extraocular muscles anchoring to the donor sclera and orbital implant, using the four full-thickness openings. The posterior face of the donor sclera, featuring the 4 full-thickness openings, is placed anteriorly in the orbit. (L) Suturing of the orbital fascia, Tenon's capsule and conjunctiva. The lateral canthotomy is also closed. A temporary transparent conformer is placed in between the conjunctival stump and the eyelids. (M) Temporary tarsorrhaphy. (N) Replacement of the temporary conformer with a custom-fitted cosmetic conformer once the healing process is over. (Post = posterior, Ant = anterior).

3.4. Orbital suture meshwork implant

Orbital suture meshwork implant can be used to bridge the orbital cavity after a transpalpebral enucleation procedure (Fig. 1-E). In 2015, a retrospective study of 37 horses assessed long-term complications and owner cosmesis satisfaction in comparison to simple enucleation [3]. It is considered as a simpler and more affordable alternative to other cosmetic solutions such as orbital implants [3]. Patients presenting with recurrent uveitis, neoplasia, globe trauma or microphthalmia can be considered for this solution. The procedure begins with a transpalpebral

enucleation (Figs. 3 & 5.A-E). Once the globe is extracted, nonabsorbable sutures are used to create the meshwork implant. Each suture strand is anchored to the orbital rim fascia and separated by a 5 mm distance [2-4]. The sutures are tied tautly to prevent the sunken appearance following eye removal (Fig. 5-F). Palpebral subcutaneous tissue and skin are sutured successively (Fig. 5-G) [3]. Reported complications include serous discharge and poor cosmesis due to breaking down of sutures, wound dehiscence, and infection. Other complications such as depigmentation of palpebral skin, disposition of palpebral skin to sunburn, persistence of palpebral reflex, uncoordinated eyelash

Table 3
Suture, implant and conformer details for orbital implant placement associated with an ocular prosthesis [4,7,24].

		Conjunctiva	Tenon's capsule & periobital fascia	Extraocular muscles	Superior conjunctival fornix	Temporary tarsorrhaphy
SUTURE	Type	Absorbable sutures (Polyglactin 910)	Absorbable sutures (Polyglactin 910)	Absorbable sutures (Polyglactin 910)	Nonabsorbable sutures (Nylon)	Nonabsorbable sutures (Nylon)
	Diameter	5-0			4-0	3-0
	Pattern	Simple continuous pattern	Simple interrupted pattern	/	Horizontal mattress pattern	Single horizontal mattress pattern
IMPLANT	Material	Hydroxyapatite + Donor sclera				
	Size	Choice of orbital implant size is not described in the literature 40 mm				
CONFORMER	Material	Porcelain Polymethyl methacrylate (PMMA)				

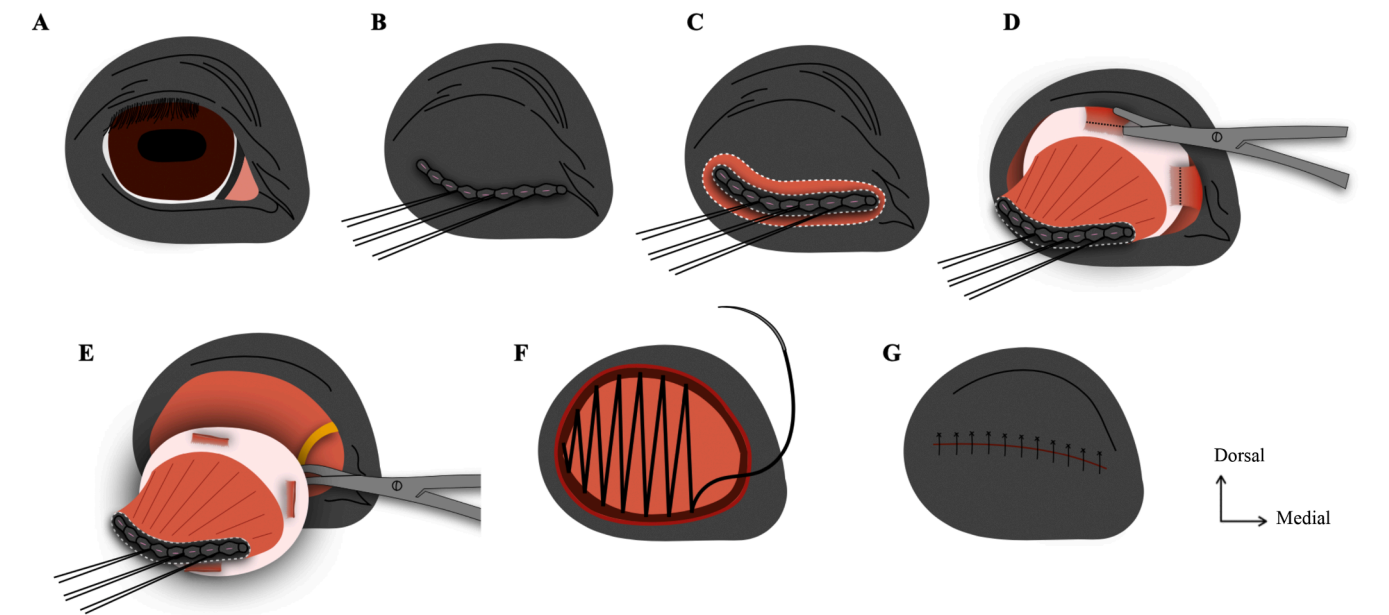


Fig. 5. Transpalpebral enucleation and orbital meshwork implant. (A-E) First steps of the previously described transpalpebral enucleation technique. (F) Anchoring of nonabsorbable sutures to the orbital rim fascia in order to create a taut cross-hatched pattern. (G) Separate eyelid subcutaneous tissue and skin closure.

growth and pruritus have been observed [3]. The surgical procedure is described in Fig. 5. Technical details for this procedure are presented in Table 4.

4. Discussion

Cosmetic outcome, return to work, owner satisfaction and complication rates are the questions of interest for the veterinarian who intends to resort to ophthalmic cosmetic solutions following eye removal surgery. Although such topics were discussed in previous publications, the number of cases was low. Four recent studies, by Maninchedda et al. in 2015 [3], Toth et al. in 2016 [5], Hupples et al. in 2017 [9] and Betbeze et al. in 2021 [21], as well as a congress proceeding by Jacopo et al. [23] brought new information on the subject and discussed other topics such as surgical site infection rates and feasibility for ocular cosmetic

procedures in standing horses. Other questions of interest refer to the choice of implant size and material, and future perspectives.

4.1. How to achieve optimal cosmesis and owner satisfaction?

When an ophthalmic cosmetic solution is requested by the owner, a thorough comparison of advantages and disadvantages of each procedure must be conducted [4,5]. Indications and contraindications, as well as owner's expectations, availability of implants and costs must be balanced. The horse's temperament should also be considered, since poor outcome in fractious horses has been reported [4]. Nowadays, owners desiring the best possible cosmetic outcome might request an intraorbital implant adjoined to a corneoscleral shell [4]. However, the recovery period is long [5,24], costs are high, and daily cleaning of the conformer is necessary [7,24]. Three of the recent publications have

Table 4
Suture and implant descriptions for orbital meshwork implant [2–4].

		Periorbital fascia	Palpebral subcutaneous tissue	Palpebral skin	
SUTURE	Type	Nonabsorbable sutures (Polypropylene)	Absorbable sutures (Polyglecaprone)	Nonabsorbable sutures (Polypropylene)	Absorbable sutures (Polyglecaprone)
	Diameter	4-0	2-0		
	Pattern	Cross-hatched grid / wheel-spoke pattern	Simple continuous pattern	Simple interrupted, cruciate or simple continuous pattern	Continuous intradermal pattern
MESHWORK IMPLANT	Material	Non-absorbable sutures (Polypropylene)			

discussed the cosmetic outcome of alternative, less expensive and time-consuming cosmetic solutions. Owner satisfaction concerning cosmesis was evaluated on 13 horses for the intraocular prosthesis [5]. Cosmesis was considered very good in 12/13 patients. Some owners opted for the additional use of a tinted bandage lens (Bandage Pat Black, tinted Bandage Lens H1 and H2 32.0-34.0 cm, Acrivet, Salt Lake City, Utah, USA) to enhance cosmesis during shows and sporting events. Therefore, this solution seems to offer an acceptable, less time-consuming alternative with an appropriate cosmesis and preservation of normal ocular motility [5]. In a retrospective study, owner satisfaction concerning cosmesis was evaluated for the meshwork implant. Cosmesis did not reach owners' expectations for this solution due to the progressive sunk-in appearance [3]. The authors proposed improvements to the procedure such as using larger than 4-0 sutures and developing better anchorage to the orbital rim fascia [3]. This has yet to be evaluated in the horse to determine if it improves owners' satisfaction on cosmesis. Another study evaluated owner satisfaction concerning cosmesis following the placement of a silicone orbital implant with sutured eyelids. Most owners seemed satisfied by the cosmetic outcome, even though some declared they would have wished a larger implant had been used [20]. This highlights the importance of properly sizing the orbital implant for a successful cosmetic outcome.

4.2. Can horses return to work after ocular cosmetic procedures?

Return to work was recently evaluated for the intraocular prosthesis and the orbital implant. Most horses (10/13) returned to work (therapy horses) and competition (high-level dressage and low-level show jumping horses) without complication. In the remaining three horses of the study, one sustained complications due to pre-existing corneal ulceration and required prosthesis removal. Two were still in the recovery period at the time of publication [5]. Another study assessed the possibility of return to work following the placement of a silicone orbital implant with sutured eyelids. 12/20 horses returned to work, but 3/20 horses had to be retired due to spooking behavior linked to blindness [20]. In comparison, 98% of the enucleated horses (84/86) in a retrospective study returned to their preoperative performance ability. This study included dressage/jumping/harness sport horses, riding school/-leisure riding horses, broodmares, and retired horses [9]. Other publications focusing on return to work after simple enucleation agree with these results, concluding that owners may be reassured that most horses will return to their performance level prior to surgery in various disciplines (showjumping, dressage, hunting, eventing, driving, showing) [21,25].

4.3. Do ocular cosmetic solutions increase surgical site infection rates?

The enucleation procedure is considered as a clean-contaminated surgery. When performed on clean eyes, surgical site infection is considered low [9]. Choosing to resort to a cosmetic solution following enucleation seems to influence surgical site infection rates. In that regard, a retrospective study concluded that silicone orbital implant placement after enucleation significantly raises the risk of surgical site infection [9]. Interestingly, another retrospective study suggested that the meshwork orbital implant procedure does not seem to increase postoperative complication rates, including infection, compared to plain transpalpebral enucleation in the horse [3]. Preexisting infection is a risk factor for postoperative complications, with or without a cosmetic solution [3,9]. Another study on silicone orbital implants with sutured eyelids advocated for the use of a checklist compiling the perioperative protocol to decrease risks of infection. None of the horses developed a surgical site infection. Recommendations include preoperative medications (antimicrobials, tetanus immunization, NSAIDs), effective cleaning and disinfection of surgical room and material, biosecurity measures (access limitation to necessary personnel) and careful patient preparation [20].

4.4. Has new information been published on other miscellaneous complications?

In the past, a slightly higher risk for miscellaneous postoperative complications such as wound dehiscence after orbital implant placement has been reported in the horse compared to a plain enucleation procedure alone [4,19]. In this regard, a 13.8% failure rate of orbital implants had been observed in a case series [19]. Recent publications advised to use pressure bandaging and meticulous tissue closure in layers to limit hematoma formation and subsequent infection [19,20]. Eyes with corneal or scleral lacerations are considered to bear a poorer prognosis for intraocular prosthesis surgical placement [5,8]. Nevertheless, case reports of successful implantation of intraocular prosthesis in horses and dogs presenting with corneal lacerations and corneal stromal abscess have been published [11,13,15]. It has been suggested that, in the presence of corneal lacerations in eyes meant to receive an intraocular prosthesis, a pedicle-type conjunctival flap can be implemented for corneal structural and nutritive support [11,13,14].

4.5. Can standing sedation be performed for ocular cosmetic procedures in the horses?

Another recent development has been the evaluation of standing sedation for the transconjunctival enucleation and silicone implant placement in the horse. Enucleation of the horse under standing sedation had been associated with a higher surgical site infection rate [9]. More recently a study assessed enucleation followed by intraorbital implant placement under standing sedation and concluded it was a safe and efficient alternative to general anesthesia in 20 horses [20]. Enucleation performed under standing sedation, with or without implant placement, requires performing locoregional ocular nerve blocks to provide proper analgesia and akinesia. Described locoregional anesthetic protocols include the auriculopalpebral nerve block, the subcutaneous palpebral ring block comprising the lacrimal, supraorbital, zygomatic, and infra-trochlear nerve blocks, and the single-point or 4-point injection retrobulbar nerve block [3,9,23,20,26]. Additional topical corneal anesthesia has been described [20].

4.6. How should the implant and prosthesis size be chosen?

Properly sizing an orbital implant means avoiding volume deficit, exceedingly deep superiorsulcus and eyelid ptosis [27]. In human medicine, implant sizing is reportedly determined predominantly during surgery with the help of ophthalmic sizers. Surgeon experience in this regard appears useful. The ideal orbital implant should provide 65 to 70% of the volume of the enucleated eye in humans. The adjoining ocular prosthesis provides the remaining volume (30 to 35%) [28]. In veterinary medicine, ideal size of an intraocular prosthesis can be estimated by measuring the normal contralateral corneal diameter with calipers and adding 1-2 mm or by assessing the anteroposterior axial diameter by ultrasonography [4,6,7]. The ideal size of an orbital implant is most often chosen subjectively by successively placing implants of different sizes into the orbit [9,19,20]. Both for the intraocular prosthesis and orbital implant in the equine patient, too-small a prosthesis might lead to an unsightly postoperative appearance while an overly large prosthesis will create undue tension and extrusion [4]. Trimming of the posterior surface can be performed so that the prosthesis matches more closely the oblate spheroid shape of the equine corneoscleral shell [5,14,15]. This would reduce implant rotation [11,19,20]. Also, the development of the orbital bony structure is dependent on the growth of the eye. Underdeveloped eyes due to early trauma and ocular inflammation or congenital defects lead to asymmetric orbits. For young animals suffering from unilateral microphthalmia, use of ocular conformers of progressively increased size or orbital implants has been mentioned in the literature [7,8]. New practical research is needed to evaluate the feasibility, efficacy and safety of this type of procedure.

4.7. How should the implant's material and shape be chosen?

Choice of material for an ocular implant is crucial. It must fill the orbital cavity throughout the entire life of the patient and be non-absorbable and biocompatible [29]. Concerning ophthalmic implant materials, very little is described in equine medicine. In human and canine medicine, silicone has been described as an appropriate non-porous substance with low complication rates [30–32]. The main reported complication is the development of an avascular fibrous capsule [30,33]. Polymethylmethacrylate (PMMA) appears to be widely used for human ophthalmic implants because of its high biocompatibility [30]. Its safety has been described in cats and dogs following enucleation [34,35]. Hydroxyapatite (HA), a ceramic material, and high-density polyethylene (PE) have gained interest over the last decades [31,36,37]. Reported complications for HA implants include conjunctival thinning, socket discharge, pyogenic granuloma formation and persistent pain or discomfort [38]. Implant porosity seems to reduce complication rates (extrusion, exposure, infection) thanks to fibrovascular ingrowth [39]. Pegging, a technique consisting of placing a peg on the ocular implant to improve cosmesis, has been evaluated in dogs with good outcomes [40]. While it has the advantage of offering more mobility to the ocular prosthesis associated with an orbital implant, this seems outweighed by its disadvantages: infection and implant exposure rates appear to be higher with this characteristic in human medicine [41].

4.8. What are the future perspectives in ocular cosmetic solutions?

Considering recent advances in new technologies, particular interest has been given to 3D-printing in veterinary cosmetic ophthalmology. In canine medicine, a 3D-printed orbital implant has been described in 2019 [42]. In the horse, a 3D-printed porous orbital implant made of biocompatible resin has been tested in cadaver heads [43]. Authors hypothesized that 3D-printing could be a safe, easy and affordable solution for animals whose owners want to resort to an ocular cosmetic solution. Further research is needed to determine if this prototype is usable in equine clinical cases. Material, manufacturing technique, surface roughness and imperfections, porosity, shape and size of the implant, ergonomics of the prototype for insertion in the orbit and suture fixation should be considered [30,31].

CRediT authorship contribution statement

J. Jarry: Writing – review & editing, Writing – original draft, Conceptualization. **A. Dugdale:** Writing – review & editing. **J.M. Vandeweerd:** Writing – review & editing, Writing – original draft, Conceptualization.

Declaration of competing interest

None of the authors has any financial or personal relationships that could inappropriately influence or bias the content of the paper.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at [doi:10.1016/j.jevs.2024.105206](https://doi.org/10.1016/j.jevs.2024.105206).

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