The use of a sling suture for ventral orbital stabilization after inferior orbitectomy in three dogs

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ABSTRACT

Objective: To describe a novel surgical technique for the ventral stabilization of the orbit after inferior orbitectomy by using a sling suture and report outcomes in three dogs.

Animals: A 7-year-old male neutered Swiss shepherd, a 4-year-old female neutered golden retriever and a 9-year-old female neutered Rhodesian ridgeback.

Study design: Short case series.

Methods: All dogs presented with caudal unilateral maxillary masses. Surgical resection necessitated a caudal maxillectomy and inferior orbitectomy with a combined dorsolateral and intraoral approach. A sling suture was used to support the globe. A nylon suture was placed rostrally through the osteotomized maxilla and caudally through the osteotomized zygomatic arch via predrilled holes. The suture was tightened until the position of the globe subjectively appeared normal and was secured with a surgeon's knot. The periorbita was secured over the nylon suture with poliglecaprone suture material in a simple interrupted or continuous pattern. The surgical approach was routinely closed.

Results: Follow-up ranged from 7 to 63 days. The surgical wounds healed uneventfully, and no postoperative complications associated with the stabilization technique were noted. No orbital deviation was noted and the zygomatic regions appeared subjectively symmetrical.

Conclusion: The nylon sling suture provided a quick, easy, safe and effective technique to stabilize the ventral orbit during a combined maxillectomy and orbitectomy in dogs.

Abbreviations: 3D - three-dimensional; β-TCP - β-tricalcium phosphate ; BMSCs - bone marrow stromal cells; BMP - bone morphogenic proteins; CT - computed tomography; FSA – fibrosarcoma; HP – handpiece; HCT – haematocrit; MRI - magnetic resonance imaging; MPNST - malignant peripheral nerve sheath tumor; MLO - multilobar tumor of bone; OSA – osteosarcoma; RI - reference interval; SCC - squamous cell carcinoma

1 INTRODUCTION

The most common oral tumors in dogs are malignant melanoma, squamous cell carcinoma (SCC) and fibrosarcoma (FSA).[1] Periorbital tumors are commonly malignant with multilobular tumor of bone (MLO), osteosarcoma (OSA), SCC and FSA being more frequent.[2] Wide surgical excision is the recommended treatment of choice for most oral tumors,[3] which in the case of periorbital and caudally located oral tumors, may require caudal maxillectomy and partial orbitectomy to achieve clear margins[4, 5]; a partial orbitectomy involves a superior or inferior orbitectomy.[6] The globe is generally preserved with a partial orbitectomy if not invaded by the tumor, in contrast, a total orbitectomy entails enucleation.[6]

The orbit includes the globe, its muscles, nerves, vessels, glands and fascia.[7] The orbit and the zygomatic arch provide stability and protection to these structures. As a result, orbital instability can occur following partial orbitectomies,[4, 5] leading to complications including strabismus, blindness, conjunctivitis, infection and neurological signs if a craniotomy is performed.[6] Furthermore, traumatic uveitis, globe rupture, retinal detachment, enophthalmos, epiphora, zygomatic duct/gland damage and altered cosmesis can also occur, depending on the degree of iatrogenic trauma.[8] It is reported that these complications are functionally and cosmetically mild and orbital stabilization is rarely indicated.[8]

In veterinary medicine, temporalis muscle flap,[9, 10] temporalis fascia transposition flap,[4] masseter muscle flap,[5] plate reconstruction,[11] and orthopedic wire covered with polypropylene mesh and a collagen sheet have been used to reconstruct the ventral orbital rim and stabilize the globe after an orbitectomy.[11, 12] Experimentally, canine zygomatic defects have been successfully repaired with three-dimensional (3D) printed tissue-engineered constructs derived from culturing autogenous bone marrow stromal cells (BMSCs) on β-tricalcium phosphate (β-TCP) scaffolds.[13] In that study, synostosis was evident between the osteotomized orbital rim edges and the induced BMSC/β-TCP implants by 12 weeks after reconstruction.[13] More recently, zygomatic arch reconstruction was successfully performed on a dog with a patient-specific 3D-printed polycaprolactone/β-TCP scaffold.[14] All of the above techniques require extensive dissection and exposure, additional implants that increase anesthetic and surgical times, costs and risk of morbidity.

In this case series, we describe the use of a sling suture to reconstruct the ventral orbital rim and stabilize the orbit, and the outcomes after an inferior orbitectomy in three dogs.

2 MATERIALS AND METHODS

2.1 Clinical history and presentation

2.1.1 Dog 1

A 7-year-old male neutered Swiss shepherd was presented to its primary veterinarian for assessment of a right caudal maxillary swelling. A magnetic resonance imaging (MRI) scan of the head revealed a mass in the right lateral maxillary area rostral and ventral to the eye. Five days later a computed tomography (CT) scan of the head at the referral hospital, revealed a soft tissue mass (60 × 30 × 50 mm) on the right maxilla, rostral and ventral to the right zygomatic arch. There was associated rostral zygomatic and maxillary cortical bone lysis (Figure 1). No signs of distant metastasis were noted in the thoracic CT scan.

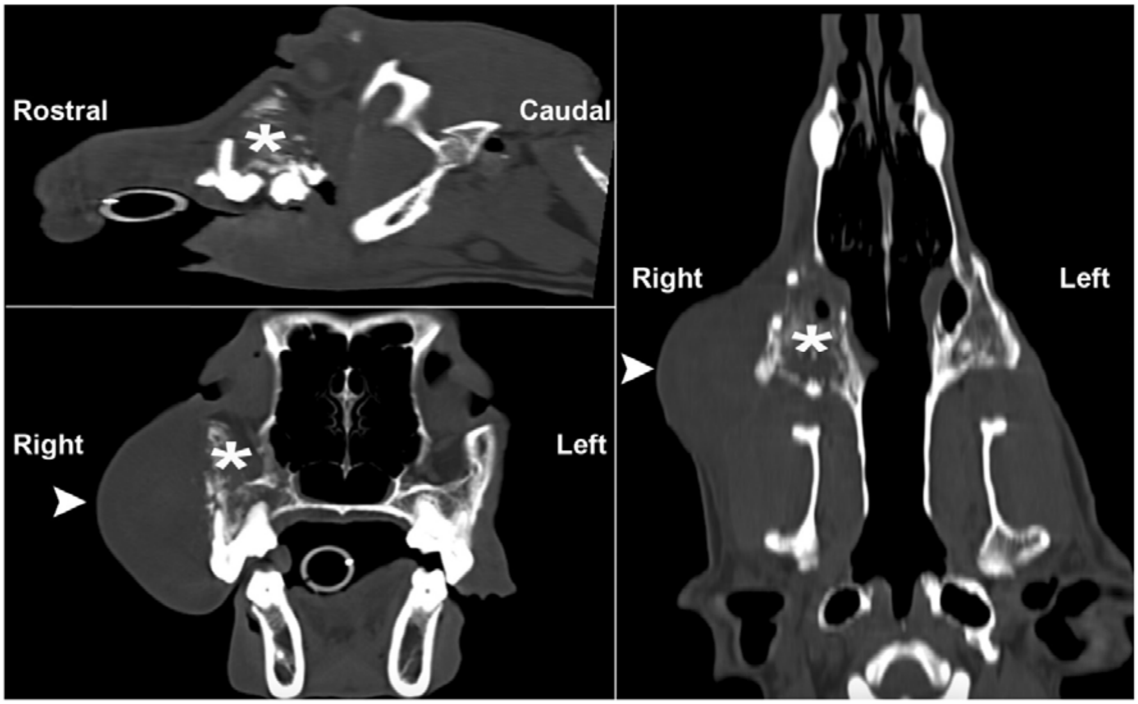

FIGURE 1. Multiplanar head computed tomography of dog 1. A soft tissue mass (60 × 30 × 50 mm) was visualized on the right maxilla (arrowhead), rostral and ventral to the right zygomatic arch. There was associated rostral zygomatic and maxillary cortical bone lysis (asterisk).

2.1.2 Dog 2

A 4-year-old female neutered golden retriever was presented for investigations of a large left maxillary mass. The primary mass was previously biopsied by the referring veterinarian and a malignant peripheral nerve sheath tumor (MPNST) was diagnosed. A CT scan of the head revealed a left-sided soft tissue mass extending from the level of the last maxillary molar tooth mediodorsally towards the ipsilateral orbit. Medially it extended into the nasal cavity towards the midline along the hard palate. There was considerable osteolysis of the maxilla (Figure 2).

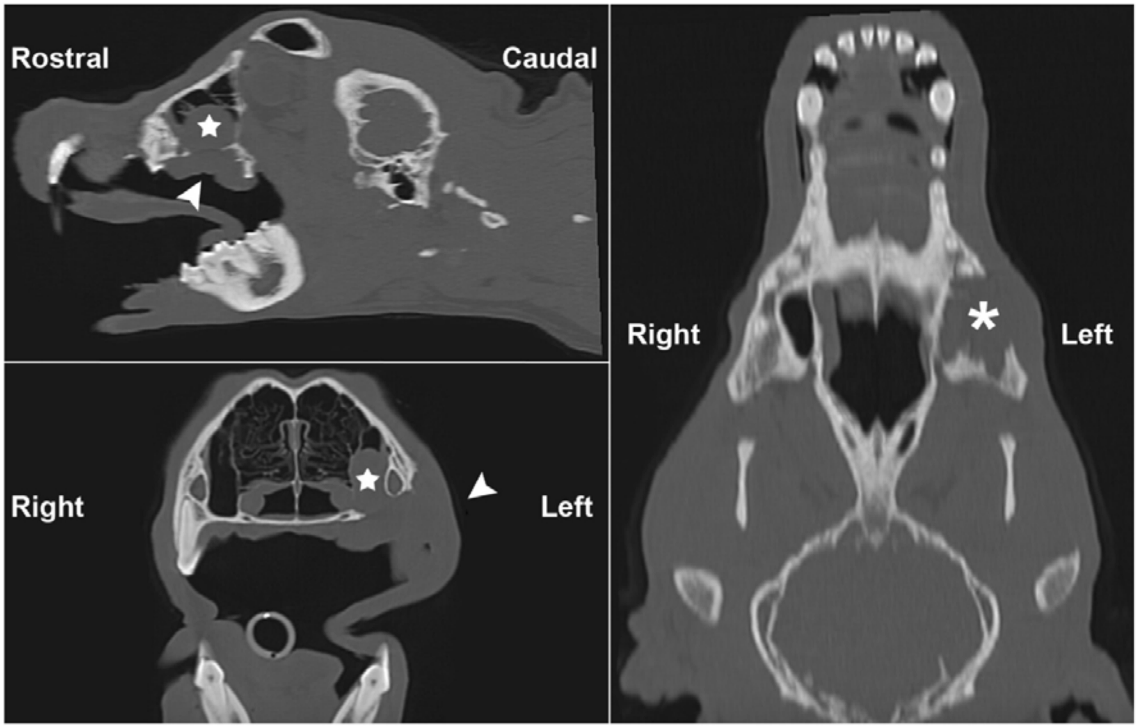

FIGURE 2. Multiplanar head computed tomography of dog 2. The left-sided soft tissue mass (arrowhead) extended from the level of the last maxillary molar tooth mediodorsally towards the ipsilateral orbit. Medially it extended into the nasal cavity (star) towards the midline along the hard palate. There was considerable osteolysis of the maxilla (asterisk).

2.1.3 Dog 3

A 9-year-old female neutered Rhodesian ridgeback presented for investigations of a large, firm, irregular mass on the left zygomatic arch under the left eye. Previous biopsies by the referring veterinarian were indicative of osteosarcoma. A CT scan of the head revealed a left-sided soft tissue mass on the ventral aspect of the left zygomatic arch; extending medially in the ipsilateral nasal cavity, cranial up to the apex of the left maxillary canine tooth (204), displacing the left globe dorsally. Marked lysis was noted on the maxillary bone and zygomatic arch (Figure 3). No metastasis was identified on thoracic CT.

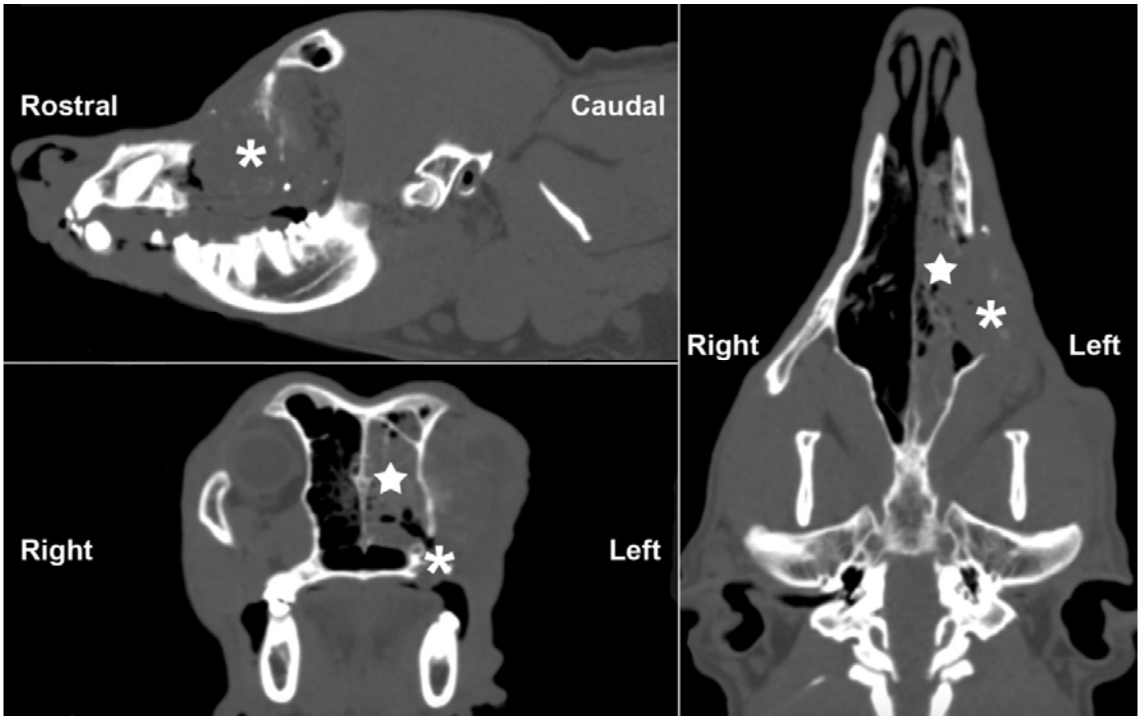

FIGURE 3. Multiplanar head computed tomography of dog 3. A left-sided soft tissue mass was identified on the ventral aspect of the left zygomatic arch; extending medially in the ipsilateral nasal cavity (star), cranial up to the apex of 204, displacing the left globe dorsally. Marked lysis was noted on the maxillary bone and zygomatic arch (asterisk).

A contrast medium was not administered in any of the CT scans performed. The regional lymph nodes were normal in size in all dogs and were not sampled. Complete blood count and serum biochemistry in all dogs were unremarkable, except for an increased hematocrit (HCT 61.3%, reference interval [RI]: 37%–55%) in dog 1 and mild azotemia (creatinine 123 µmol/L, RI: 40–111, urea 10.8 mmol/L RI: 2.3–8.9) in dog 3.

2.2 Surgical procedure

The surgical technique in all three dogs was similar and thus described together. The affected side of the face was clipped of hair and aseptically prepared with a combination of 2% chlorhexidine solution on all areas of the skin, and an alcohol spray on the muzzle and cheek only. Sterile lube was applied to the cornea to protect it while clipping, and a sterile gauze was used on the eye while applying the alcohol spray. The cornea was then rinsed with sterile saline to remove the lubrication applied. The oral cavity was rinsed with an 0.12% chlorhexidine oral rinse solution. The dog was positioned in lateral recumbency with the affected side of the maxilla uppermost. No regional nerve blocks were performed to prevent seeding of the neoplastic cells. A combined dorsolateral and intraoral approach to the maxilla was performed, as described by Lascelles et al.[15] Briefly, an incision was started on the dorsal midline dorsomedial to the medial canthus, and extended below the lower eyelid, following the contour of the orbit, extending caudally to the level of the orbital ligament. The intraoral incision was planned based on the CT scan findings, and the visual soft tissue lesion, to achieve at least a 10 mm margin around the gross lesion. The soft tissues were incised with a Colorado microdissection needle (Stryker, Germany) mounted on a monopolar unit. Depending on the dog, the appropriate dorsal, rostral, caudal and ventral osteotomies were performed with a size 4 (1.4 mm diameter) round handpiece (HP) tungsten carbide bur mounted on an electric drill to complete the planned caudal maxillectomy (Figure 4B). In dog 1, the osteotomy extended from mesial to the right maxillary third premolar tooth (107) to half of the zygomatic arch length caudally, up to one quarter of the width of the maxillary bone and three quarters of the height of the maxillary bone. In dog 2, the osteotomy extended from mesial to the left maxillary third premolar tooth (207) to one third of the zygomatic arch length caudally, up to half of the width of the maxillary bone and three quarters of the height of the maxillary bone. In dog 3, the osteotomy extended from mesial to the left maxillary second premolar tooth (206) to approximately half of the zygomatic arch length, up to half the maxillary bone in width and height, entering the contralateral nasal cavity. The lacrimal and palatine bones of the orbit were left intact in dogs 1 and 2, while part of the lacrimal and palatal bones were resected in dog 3. A partial inferior orbitectomy was necessary for all dogs to achieve wide surgical margins. The periorbita was separated from the zygomatic arch with a combination of sharp and blunt dissection, leaving the conjunctival sac intact.

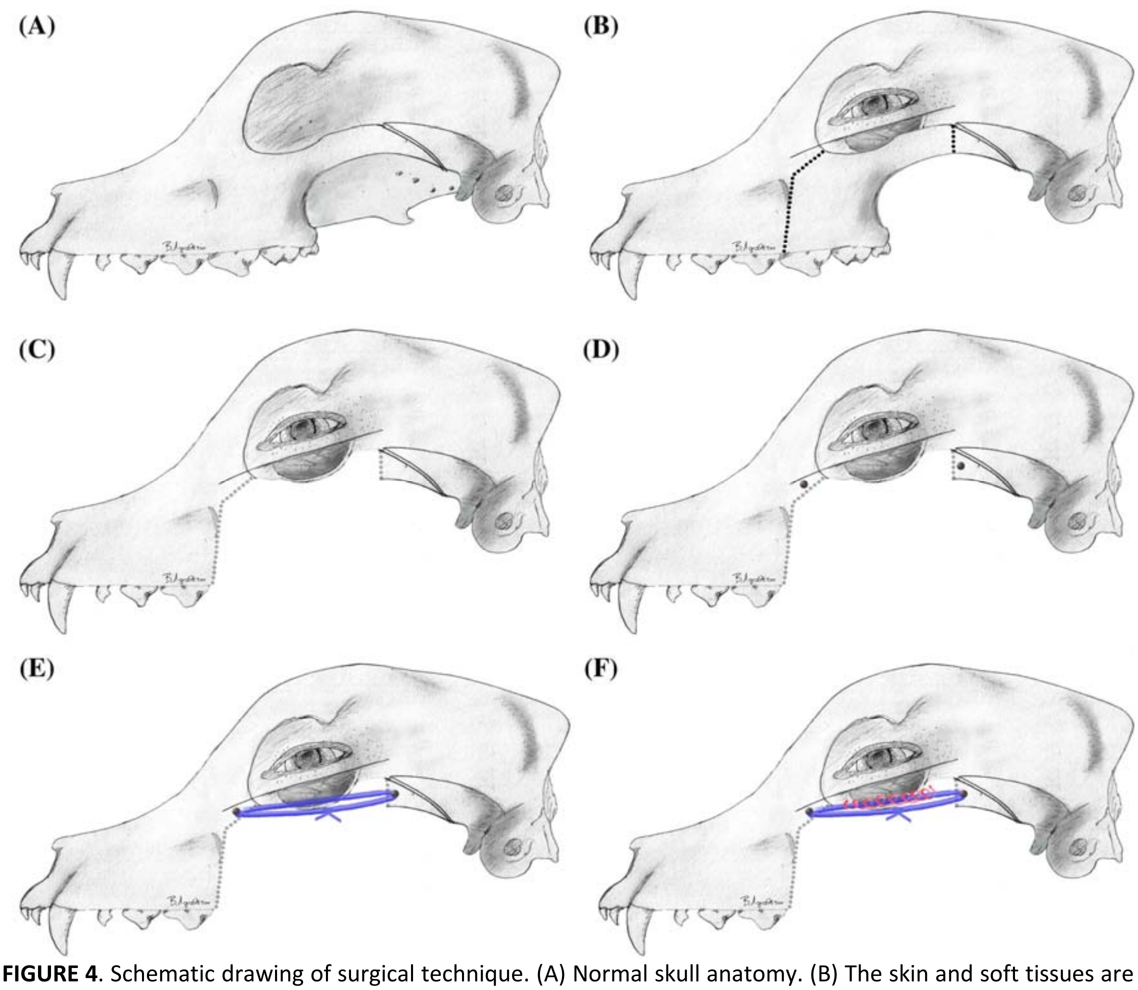

FIGURE 4. Schematic drawing of surgical technique. (A) Normal skull anatomy. (B) The skin and soft tissues are incised and transected to prepare for the ostectomy. Intended caudal maxillectomy and orbitectomy margins are delineated by dotted lines. The pterygoid bone has been removed for demonstration purposes. (C) The maxilla and zygomatic arch are resected and the orbit and periorbital tissues are now unsupported. (D) The two drilled holes are performed 5 mm away from the osteotomy sites. (E) The nylon suture is passed through the

drilled holes and tightened until the globe appears in a normal position. (F) The periorbita is secured over the nylon suture in a simple continuous or interrupted pattern with poliglecaprone suture.

Following mass resection (Figures 4C and 5A), two holes were created to allow for the passage of the sling suture (Figures 4D and 5B). The rostral hole was drilled on the remaining maxillary bone, while the caudal hole was drilled on the preserved *pars temporalis* of the zygomatic arch. Both holes were drilled ~5 mm away from the osteotomy sites with a size 4 (1.4 mm diameter) round HP tungsten carbide bur. A nylon (Ethilon, Ethicon, UK) size 0 suture material (dog 1 and 2) or nylon size 2–0 (dog 3) was inserted through the predrilled holes and situated ventral to the globe to support it. A second loop was inserted as necessary to support the orbit (dog 3). The sutures were tightened up to the point that the location of the globe subjectively appeared normal and was secured with a surgeon's knot (Figures 4E and 5B). The periorbita was wrapped around the nylon suture and secured in place using poliglecaprone (Monocryl, Ethicon, UK) size 4–0 suture material in a simple interrupted or continuous pattern (Figures 4D and 5C). The position of the globe was reassessed before the routine closure of the skin incision and intraoral approach (Figure 5D).

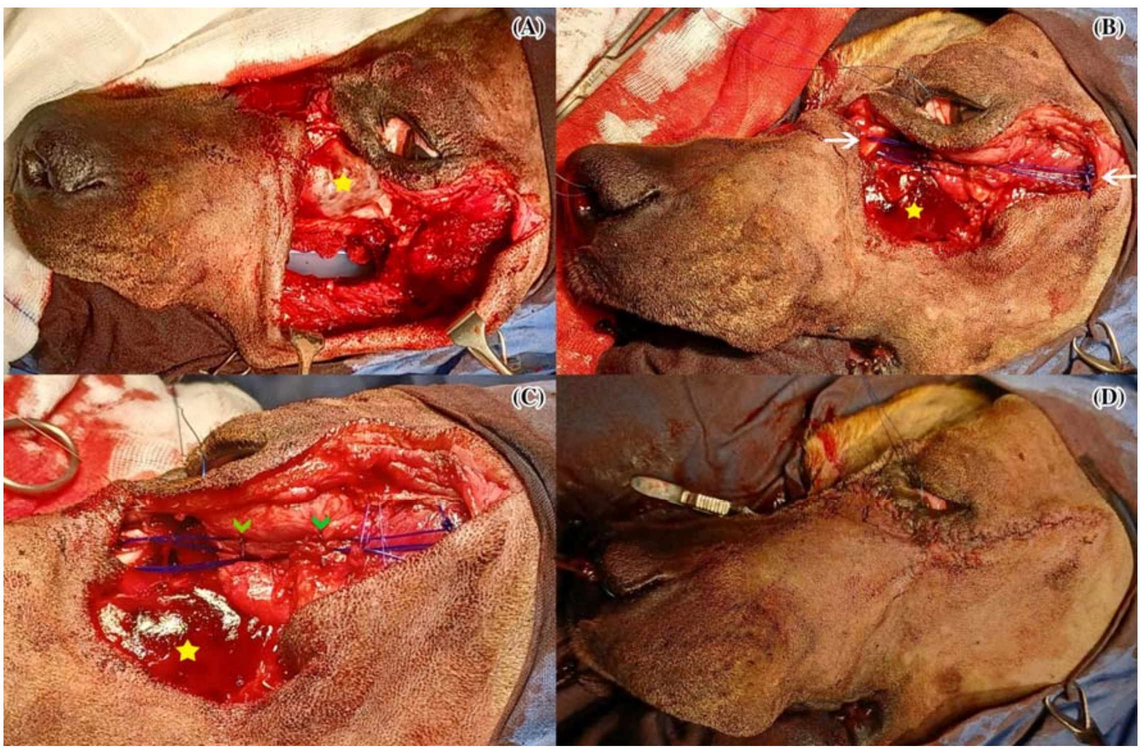

FIGURE 5. Intraoperative images from dog 3. (A) Surgical site with dorsolateral and intraoral approach following mass removal. (B) Double looped sling suture has been placed through the cranial maxillary drilled hole and caudal zygomatic arch remnant (white arrow). (C) The sling suture was sutured to the periorbita with a continuous pattern. The green arrowheads indicate the knots from the continuous pattern. (D) Cosmetic appearance following surgical closure. A collagen sponge was placed in the nasal cavity to assist with hemorrhage and blood aspiration (yellow star [A], [B], [C]).

Dog 1 was discharged 3 days following surgery, with oral amoxicillin/clavulanic acid 20 mg/kg and carprofen 4.4 mg/kg, each for 5 days. Dog 2 was discharged 3 days following surgery with oral carprofen 4.4 mg/kg once daily for 5 days, and cephalexin 20 mg/kg twice daily for 7 days. Dog 3 was discharged 3 days following surgery with oral paracetamol 15 mg/kg twice daily for

7 days, gabapentin 10 mg/kg twice daily for 7 days and meloxicam 0.1 mg/kg once daily for 3 days.

3 RESULTS

3.1 Outcome

Histopathology from the submitted maxilla from dog 1 was consistent with a completely excised high-grade osteosarcoma with extensive involvement of the surrounding bone and soft tissues. Histopathology from dog 2 was consistent with a completely excised high-grade sarcoma with the morphological features and growth pattern of an MPNST. No immunohistochemistry was performed. Histopathology from dog 3 was consistent with a rostrally and dorsally incompletely excised osteosarcoma.

FIGURE 6. Dog 1 represented 18 days postoperatively. (A) The lateral right head image has been flipped horizontally for easy comparison of the symmetry to the left lateral head image (B). Dog 2 represented 63 days postoperatively. Image of the left side of the head (C) and a portrait image with the dog looking forwards (D), showing normal orbital positioning and symmetry with the contralateral globe.

One week following surgery all dogs presented to the referral hospital for re-examination. No concerns were reported by the owners. The skin and oral surgical wounds had healed uneventfully, and no ventral or lateral deviation of the globe was noted on facial examination. No ocular abnormalities were observed in terms of eye movement or vision. Both sides of the face were symmetrical when examining the positioning of the globe, with absent strabismus, enophthalmos or orbital instability. Dogs 1 and 2 were re-examined at the referral hospital 18 and 63 days postoperatively, respectively, and the orbital symmetry was unchanged (Figure 6).

Dog 1 presented to the primary veterinarian 8 months postoperatively with labored breathing, presence of diffuse right-sided respiratory crackles, abdominal pain and a large lumbosacral subcutaneous mass lesion. The oral and skin incisions were reported normal with no visible tumor recurrence. The dog was euthanized on humane grounds with no further investigations. Dogs 2 and 3 were lost to follow-up after their last postoperative examination.

4 DISCUSSION

We describe a new technique for stabilization of the orbit following an inferior orbitectomy. A nylon sling suture was placed through predrilled holes from the caudal maxilla to the rostral segment of the zygomatic arch to mimic the resected zygomatic arch. The suture was tightened as needed to hold the globe in a subjectively normal position and secondly, the periorbita was wrapped around the sling and secured with a continuous suture pattern.

Some of the complications of inferior orbitectomies include enophthalmos, strabismus, blindness, epiphora, cosmetically altered appearance and dystopia.[6, 8] Dystopia derives from the Greek words “dys” and “topos” translating into “bad place”, meaning something that is not in the correct position. In the case of ocular dystopia, it means that the globes are not positioned at the same height. In people, diplopia (double vision) is also a reported complication.[16] Orbital reconstruction is not only performed for cosmetic purposes but also to avoid all of the above consequences and to preserve eye function.

In people, facial reconstruction following maxillectomy can be performed with soft tissue and bone flaps,[17] bone grafts combined with soft tissue flaps,[18] free vascularized soft tissue flaps alone or free vascularized/pedicled composite flaps with bone, or a combination of soft tissue flaps with prostheses.[17] The main drawbacks of autologous bone grafts are donor site morbidity, increased surgical time, inability to contour easily and unpredictability in resorption which alters the cosmesis.[19] Furthermore, they are also less resistant to infection, especially following radiotherapy.[20] Free vascularized soft tissue and composite flaps are commonly used for orbital reconstructions in people due to their direct blood supply, superiority to withstand radiation and provide reliable and permanent support to the globe.[20] However, their disadvantages lie in the muscles they consist of, which may atrophy with time, leading to loss of volume and altering the esthetic effect of the reconstruction.[20] Three-dimensional printed titanium mesh has been described in conjunction with free or pedicle muscle flaps.[21] This provides better precision in the reconstruction, although it is costly, and has the risk of corrosion, ion reaction and exposure, especially following radiotherapy.[21, 22]

Veterinary techniques for orbital reconstruction are much more limited compared to those described in the human literature. Temporalis muscle flap,[9, 10] temporalis fascia transposition flap,[4] masseter muscle flap,[5] plate reconstruction,[11, 23] patient-specific implants,[13, 14] and orthopedic wire covered with polypropylene mesh and a collagen sheet have been described in dogs for orbital rim reconstruction.[11, 12]

A temporalis muscle flap has been successfully used for the treatment of an orbitonasal fistula in a dog.[9] The fistula was a result of radiotherapy after zygomatic arch resection for a zygomatic adenocarcinoma.[9] The reported complications using this technique were pain on mastication, as well as facial and trigeminal nerve injury.[9] More recently, Dent et al.[4] reported the use of a temporalis fascia transposition flap for orbital reconstruction after an inferior orbitectomy.[4] Mild epiphora and minimal ventral deviation of the globe were reported in the early postoperative period and minimal facial asymmetry was seen by the owners in the long term with this technique.[4] Further extension of the surgical incision is necessary to create the temporalis fascia flap which could increase the surgical time, as well as the morbidity. The authors suggested that the use of fascia rather than a muscular flap would prevent the esthetic changes that would occur after inevitable muscle atrophy.[4] A masseter muscle flap with preservation of the periosteum over the dorsal zygomatic arch to suture the flap to, has also been described.[5] Bone formation was evident 8 months postoperatively on the repeated CT scan, as the periosteum acted as a scaffold for new bone formation.[5] This provided extra stability to the reconstruction and no orbital deviation was seen long-term. The disadvantage of this technique is that the masseter muscle can be infiltrated by neoplastic disease and is not always available for reconstruction.[5] The use of autologous tissues for orbital reconstruction has the advantage of not using foreign material and the absence of implant-related complications and reactions. They do, however, increase the dissection and surgical time, have the potential for donor site morbidity and could cause tumor seeding. Resorption of the autologous tissues, altered cosmesis and increased infection rate may also be more common in people receiving adjuvant radiotherapy.[19, 20]

With prostheses, no additional dissection is necessary; however, the cost increases due to the additional implants needed. Orthopedic wire covered first with a polypropylene mesh and then a collagen sheet to cover the mesh has been reported by Wallin-Håkansson and Berggren[11] to reconstruct the orbital rim in four dogs and a cat.[11] In one of the four dogs, a 3.5 mm reconstruction plate was initially used to replace the zygomatic arch, but the lateral orbital rim and orbital ligament were mimicked with orthopedic wire from the zygomatic process to the plate.[11] The authors of this study reported both eyes being visual, with normal movement, alignment and positioning at a follow-up of up to 3 years.[11] Although normal eye positioning was noted in all dogs, two had a large concavity below the eye which was due to the extent of the maxillectomy.[11] In a recent poster presentation, cerclage wire with (9/14) or without (5/14) polypropylene mesh was used to reconstruct the maxillary and zygomatic defects, following caudal maxillectomy and zygomatic arch resection.[12] Revision surgery was required in 4/14 dogs, all of which had a polypropylene mesh implanted and required the mesh to be removed.[12] The researchers speculated that the contradicting results compared to Wallin-Håkansson and Berggren[11] was that the former group used the mesh for the maxillectomy reconstruction as well as zygomatic, and as a result, the mesh was in contact with the nasal cavity, leading to increased complications.[11, 12] Despite this, the outcome was good both cosmetically and functionally in all dogs.[12]

The experimental reconstruction of canine zygomatic defects with 3D printed tissue-engineered constructs from autogenous BMSCs on β-TCP scaffolds were successful in reconstructing the zygomatic arch with new bone formation.[13] Similar techniques relying on new bone formation may be further explored in the future, however, costs can be prohibitive. In addition, for dogs where adjuvant radiotherapy may be indicated soon after surgery, it may need to be postponed until the bone formation is complete to avoid inhibition of healing. The risk of implant exposure, especially after radiotherapy,[21, 22] needs to be considered in dogs reconstructed with implants. The use of BMSCs in a surgical site with persistent neoplastic cells is contraindicated in cases with osteosarcoma in people, as it can promote tumor growth.[24, 25] Similarly, bone morphogenic proteins (BMP) have been successfully utilized for bone regeneration in mandibular defects following mandibulectomies in dogs, but can increase costs heavily and again are contraindicated in tumor-laden surgical beds.[26, 27]

The sling suture technique we describe does not require any expensive equipment or implants. Nylon suture is readily available and inexpensive and provides a quick and stable reconstruction without the need for any additional surgical exposure. From the authors' experience, the surgical time to perform the sling suture was very short and the technique was easy to perform. No tissue healing is required for the stabilization technique itself, and adjuvant radiotherapy can be initiated as soon as necessary. Furthermore, the risk of tissue irritation or suture exposure following radiotherapy is mitigated with this technique. No wound or implant-related complications were identified in the three dogs reported here, although no radiotherapy was performed in any of the dogs. The globes were in normal position and symmetrical, with no strabismus, enophthalmos or orbital deviation. No orbital asymmetry was noted in dog 1 even 8 months postoperatively.

One of the functions of the zygomatic arch, apart from providing support to the orbit, is protection from trauma. The drawback of the sling suture technique compared to the regenerative techniques, and plate or wire reconstruction is that it does not protect the orbit against trauma. The sling suture does not have the inherent robust strength of all the aforementioned stabilization techniques, which is its only disadvantage. Another limitation is the use of nonabsorbable material in an area that potentially has residual neoplastic disease present, and the fact that two dogs were lost to follow-up at 18 and 63 days postoperatively.

In conclusion, we describe a novel technique for the reconstruction of the orbital rim following an inferior orbitectomy. We successfully used a nylon sling suture to replace the support of the resected zygomatic arch, with no intraoperative or postoperative complications reported with this technique. Further dogs would be required to fully assess complications and long-term outcomes. This sling suture can be considered for an easy, short and inexpensive orbital reconstruction.

AUTHOR CONTRIBUTIONS

Logothetou V, DVM, MRCVS: Collecting data, drafting and revising the manuscript, drawing of sketches and editing. Almansa Ruiz JC, DVM (Hons), MSc (Vet), Dipl. EVDC, MRCVS: Performed the surgeries, manuscript revision and editing. Steenkamp G, BSc, BVSc, MSC (Zool), PhD, FRCVS: Conception of the surgical technique, performed the surgeries, manuscript revision and editing.

CONFLICT OF INTEREST STATEMENT

The authors have no conflicts of interest to declare. No external funding has been received for the conduction of this study.

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