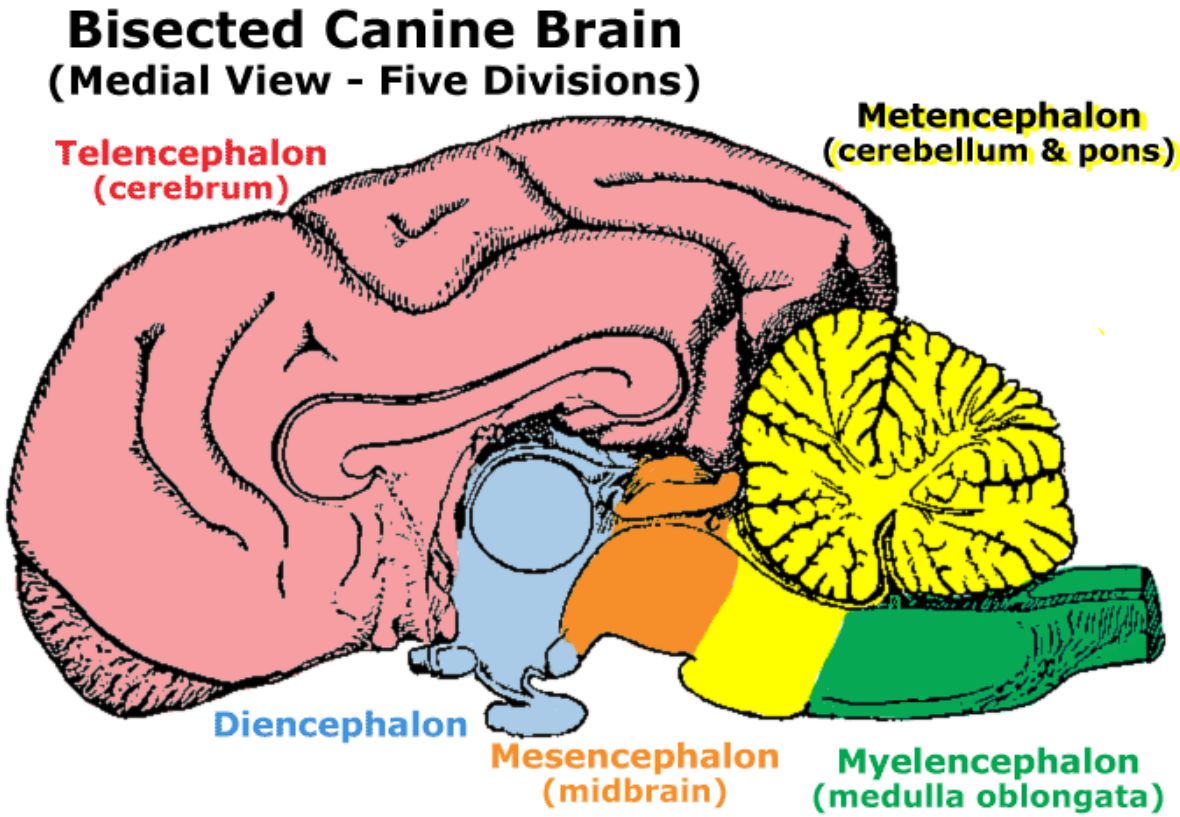
개, 고양이 뇌신경계 질환의 수술적 치료

이서윤 외과과장

비엔동물전문의료센터
BIEN ANIMAL MEDICAL CENTER

Anatomy: Brain lobes

Forebrain
- Mental deficits (contralateral)
- Seizures
- Circling (ipsi)
- Head turn (ipsi)
- Postural reaction and visual deficit (contra)

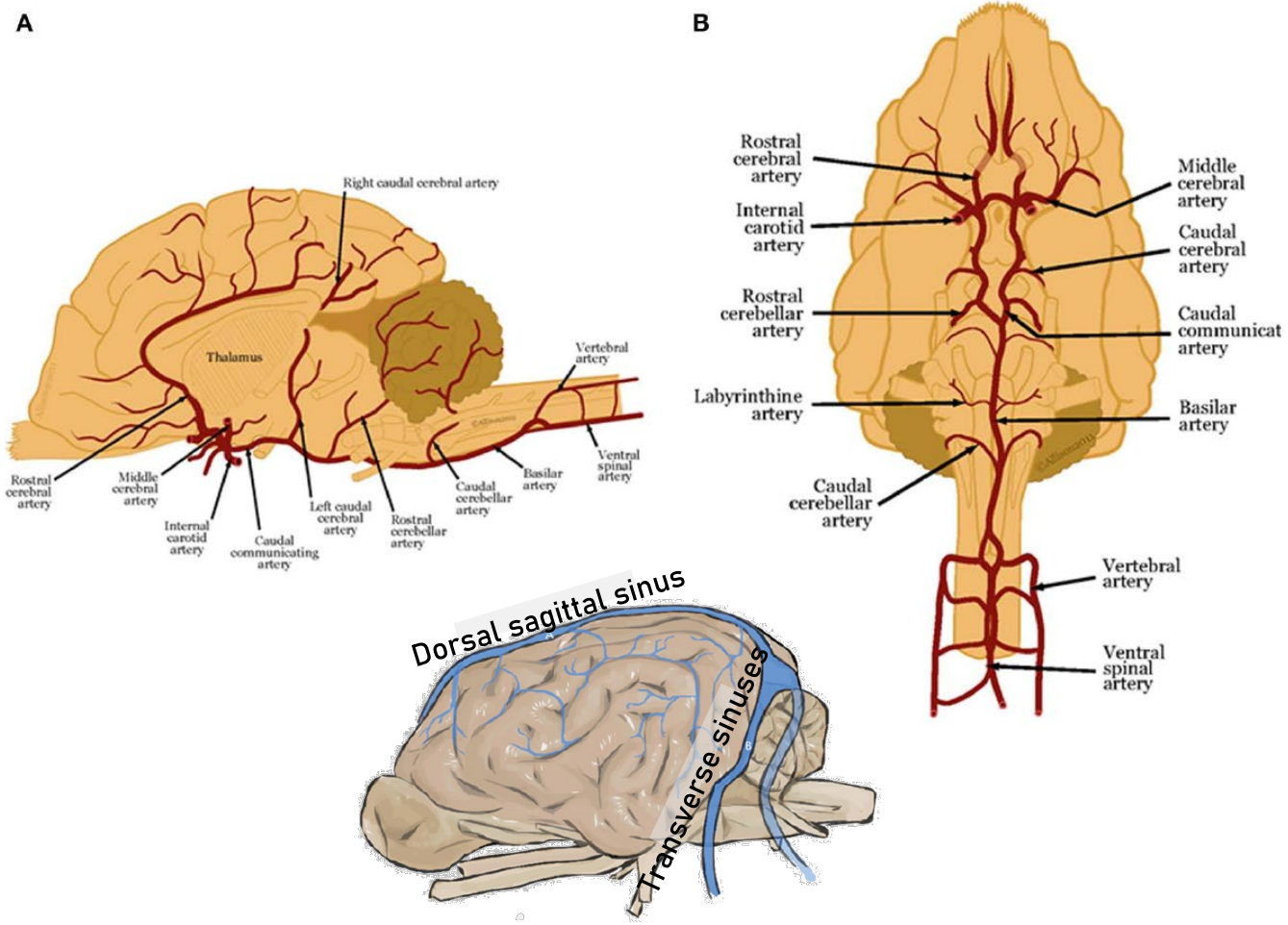


Cerebellum
- Ataxia
- Dysmetria
- Intention tremor
- Broad based stance

Brainstem
- Cranial nerve deficits
- Postural reaction deficits
- Paresis (ipsi)
- Cardiac/respiratory
- Sleep abnormalities

Vestibular
- Ataxia
- Falling, rolling, head tilt toward side of lesion
- Nystagmus

Anatomy: Vessels



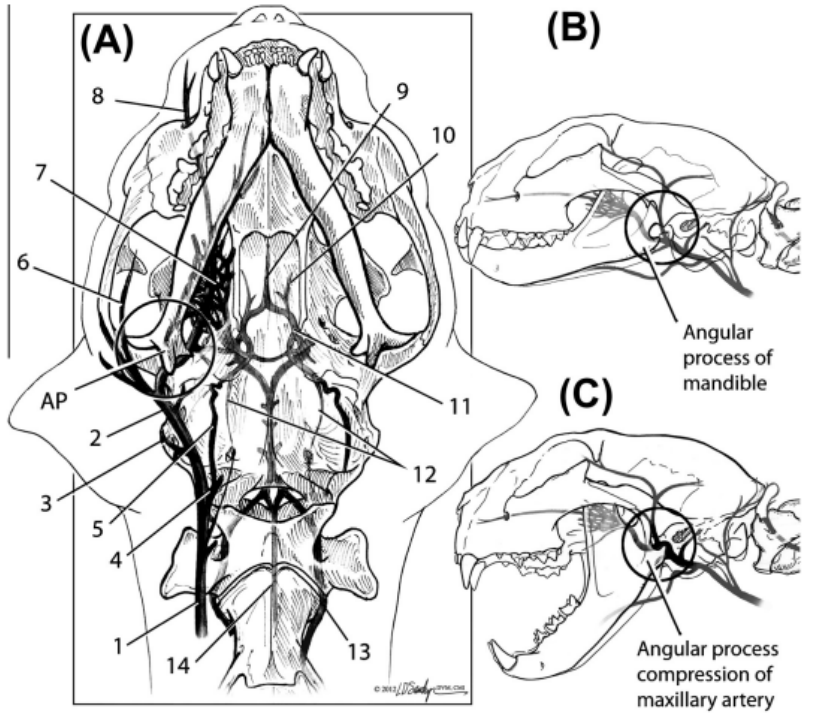
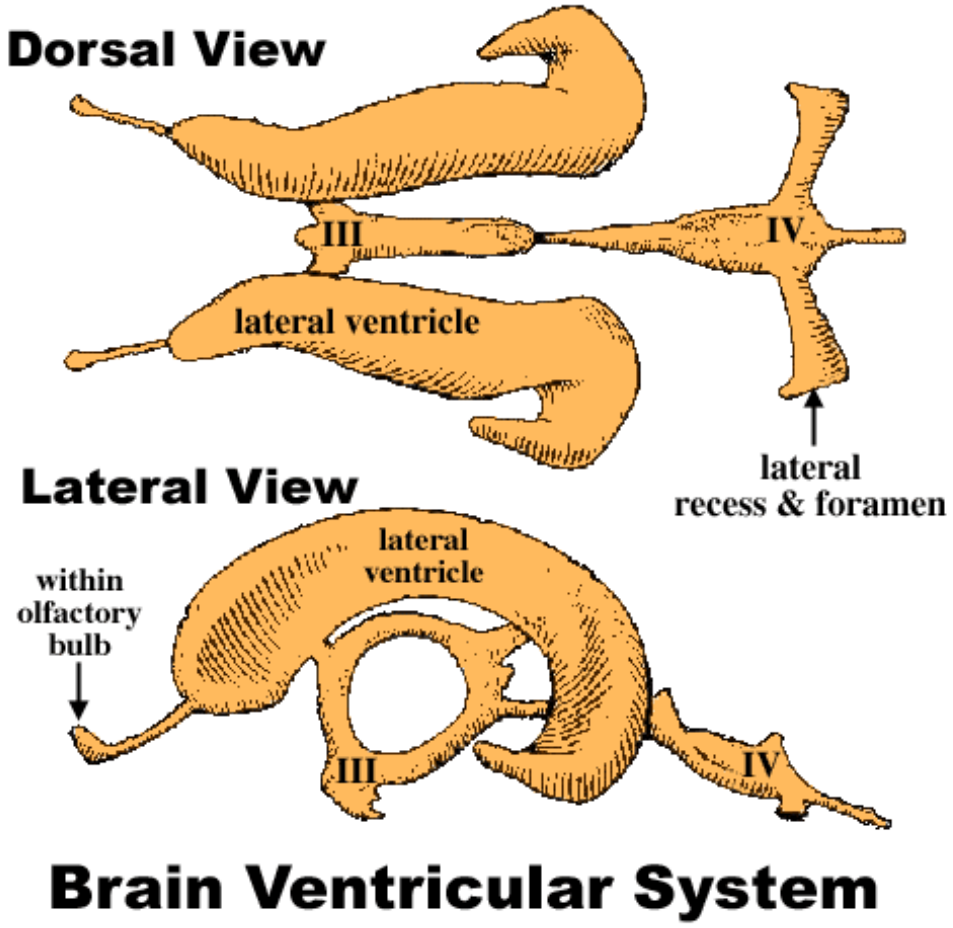
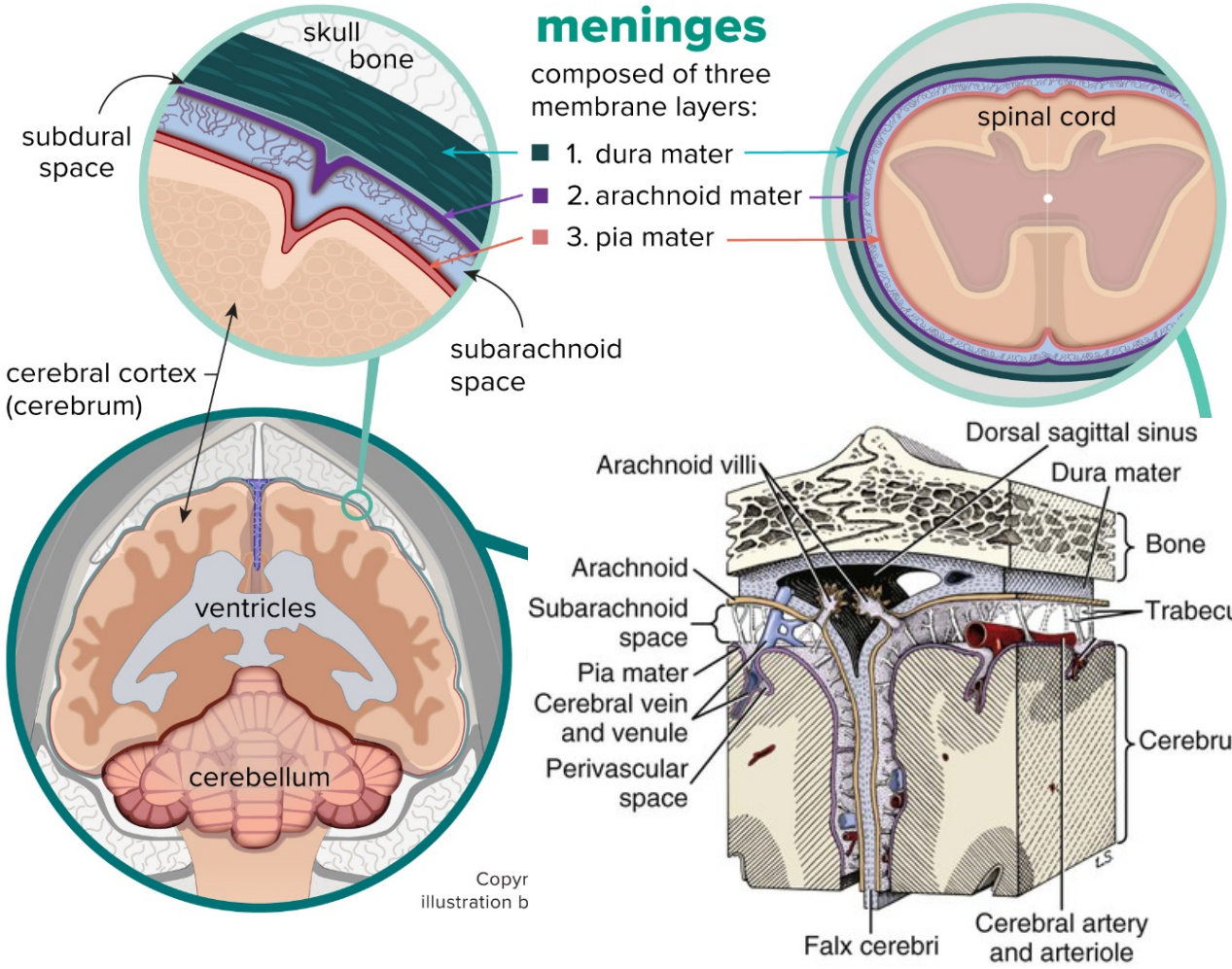


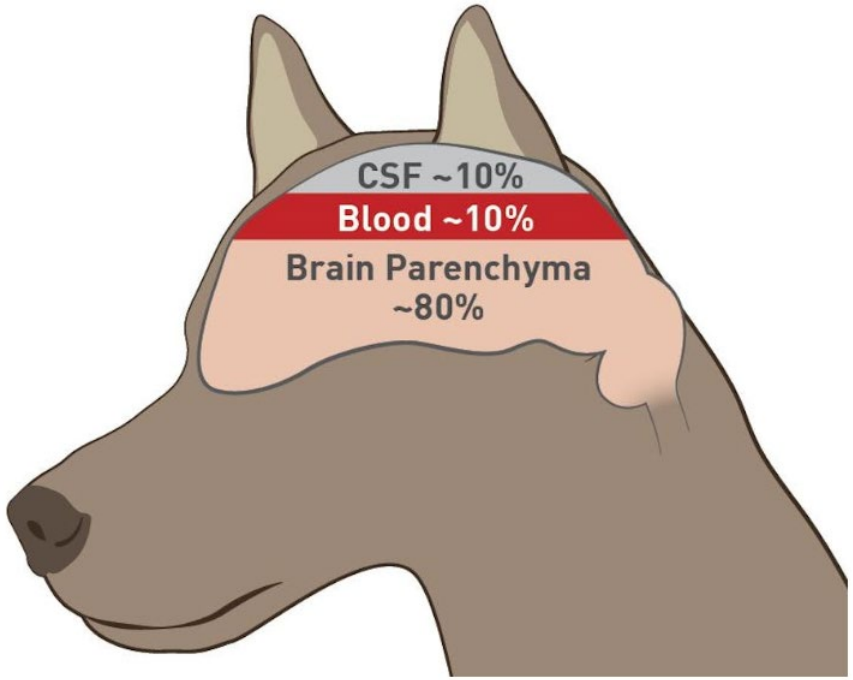
Fig. 1. Illustrations showing the primary arterial blood supply to the brain, ears, and eyes via the rete branches of the maxillary arteries. (A) Ventral view of the head and cranial neck. (B) Left-lateral view of the head with the mouth closed. (C) Left-lateral view of the head with the mouth open. Compare (B and C). Note the proximity of the angular process of the mandible and the maxillary artery, and how the relationship varies with mouth positioning. 1 – Common carotid artery, maxillary artery (unlabeled) is included in circle as an extension of (2); 2 – external carotid artery; 3 – occipital artery; 4 – ascending pharyngeal artery; 5 – anastomotic branch of the ascending pharyngeal artery with the internal carotid artery; 6 – superficial temporal artery; 7 – rete mirabile arteria maxillaris; 8 – infraorbital artery; 9 – rostral meningeal artery; 10 – rostral cerebral artery; 11 – cerebral vascular circle (circle of Willis); 12 – internal carotid artery; 13 – vertebral artery; 14 – ventral spinal artery.

Anatomy: Ventricles, meninges





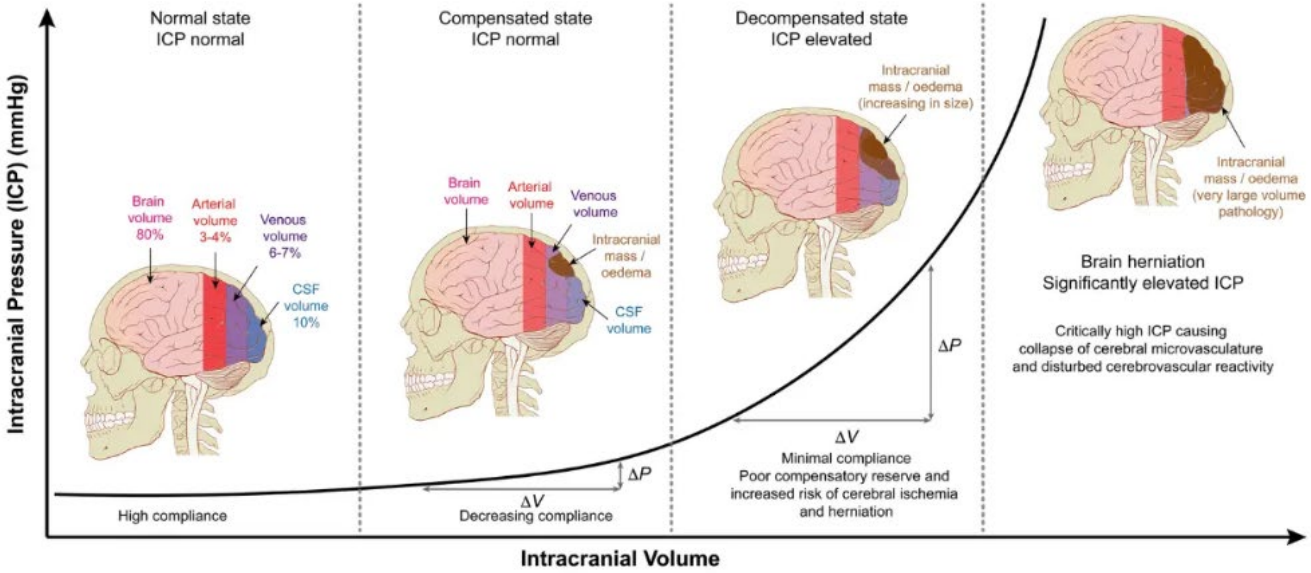
Monro-Kellie Doctrine



The reference range for ICP in clinically normal dogs ranges from 0.67 to 1.60 kPa (5 to 12 mm Hg)

CPP = MAP – ICP

- CPP = cerebral perfusion pressure
- MAP = mean arterial pressure
- ICP = intracranial pressure



Increased Intracranial **Pressure** (ICP)

Causes

Space-occupying lesions
- Intracranial mass
- Abscess
- Hemorrhage
- Arteriovenous malformation

Focal or diffuse cerebral edema
- Trauma
- Toxic
- Anoxia

Reduction in size of the cranial vault
- Craniosynostosis
- Thickening of skull

Blockage of CSF flow
- Non-communicating hydrocephalus

Reduction in CSF reabsorption
- Communicating hydrocephalus
- Meningitis
- Elevated cerebral venous sinus pressure
- Elevated CSF protein

Increased CSF production

Idiopathic intracranial hypertension

Evidence of elevated ICP

- Vomiting
- Deteriorating neurological state
- Cushing's reflex
  : systemic hypertension and bradycardia
- Papilledema

➔ If left untreated, the animal can suffer detrimental effects such as brain herniation and death.

Intracranial Surgery in Dogs and Cats

- Head trauma
  - Depressed fractures
  - Penetrating foreign bodies/projectiles
  - Hematoma evacuation
- Intracranial and extracranial masses
  - Neoplasia
  - Abscesses
- Shunt placement and marsupialization
  - Hydrocephalus
  - Quadrigeminal diverticulum
- Chiari-like malformation

Skull tumor

Classic presentations

- Young dog w/ slowly growing mass
- Geriatric dog w/ newly discovered mass
- Rarely, soft tissues & brain parenchymal invasion
- More commonly, act as a space-occupying lesions

Tumor types

- ✓ Multilobular osteochondrosarcoma
- ✓ Osteoma
- ✓ Osteosarcoma
- ✓ Chondrosarcoma
- ✓ Squamous cell carcinoma
- ✓ Fibrosarcoma

Clinical signs

- Asymptomatic in most cases
- Near the TMJ or orbit, or it invades the sinus
- If parenchymal compression occurs,
  - Changes in mentation
  - Circling, ataxia, seizures etc.

Diagnostic work-up

- A full physical examination
- Health screening (CBC, S/C, U/A, X-ray, Abdominal U/S)
- FNA & cytology
- Incisional biopsy (after advanced imaging)
  - Jamshidi needle or Michele Trephine instrument
  - Biopsy tract need to be removed during surgery

Diagnosis

Radiographs
- Mass size, cranial involvement, metastasis (thorax)

CT
- Anatomical localization & overview for surgical planning

MRI
- Parenchymal change & better delinate important vascular structures

- The feasibility of surgical excision is dependent on the location and extent of the tumor.

1. The dorsal sagittal & transvers venous sinuses
2. Contrast enhancement within the temporalis m.
3. Involvement of the frontal sinus or cribriform plate

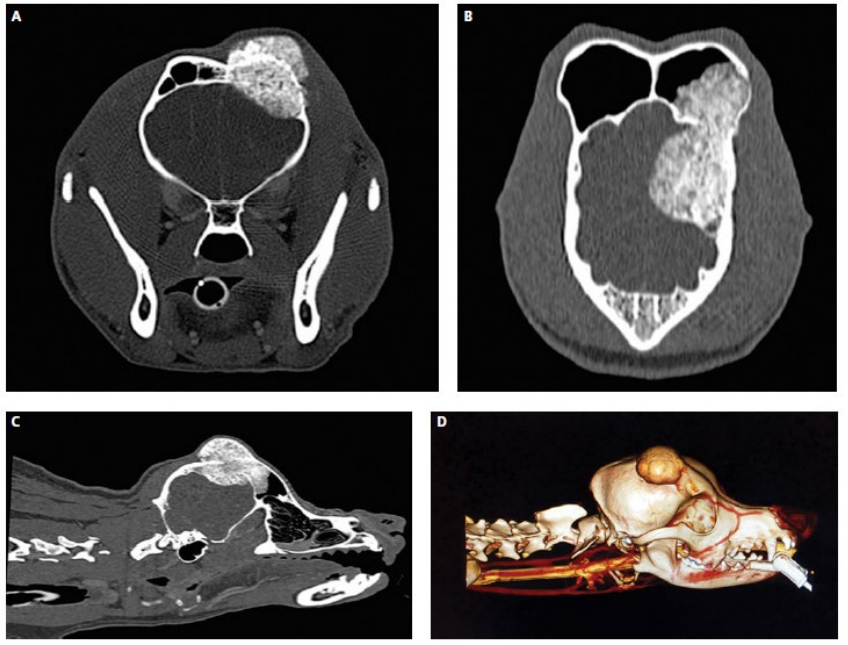


Figure 13.1 (A) Transverse, (B) dorsal and (C) sagittal reconstructed CT images of a skull osteosarcoma. (D) A virtual three-dimensional reconstruction has also been created for planning.

Diagnosis

Radiographs	• Mass size, cranial involvement, metastasis (thorax)
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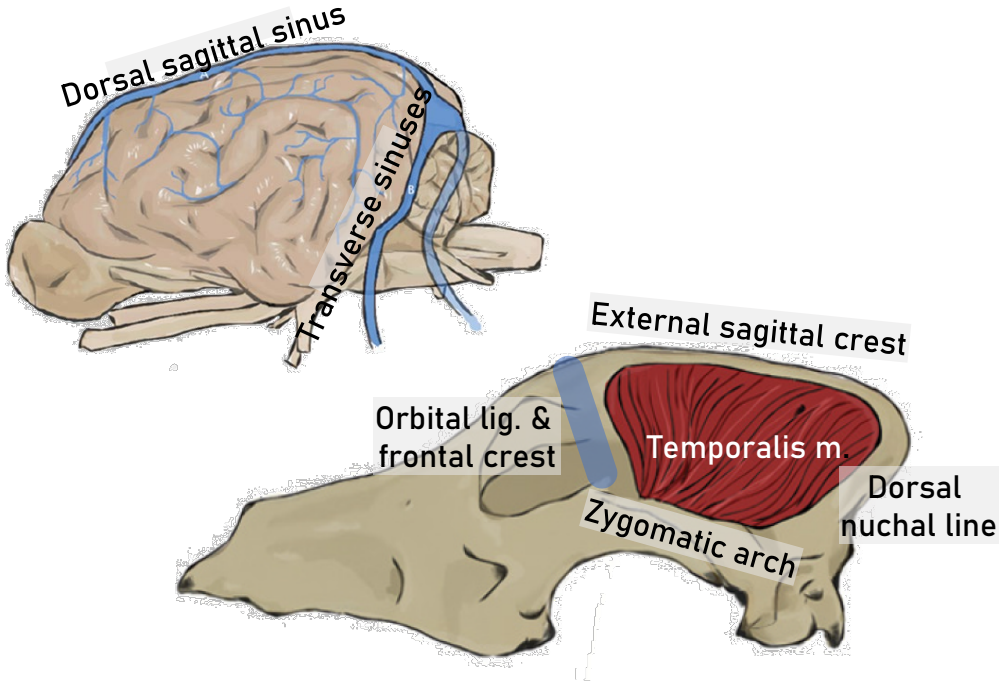
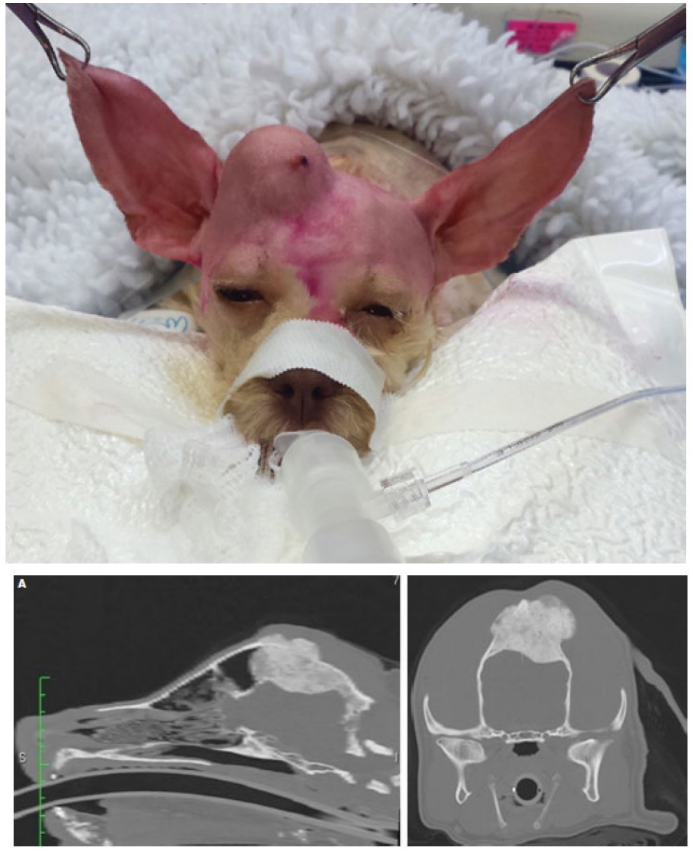
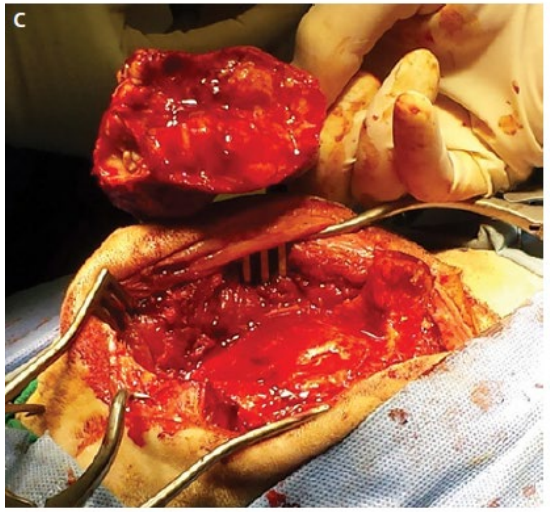


Surgical Treatment



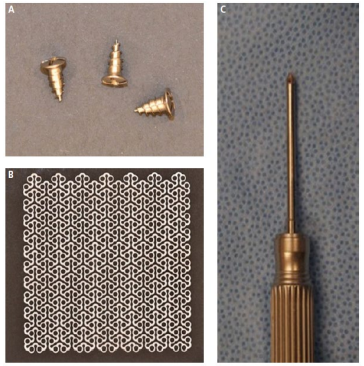
Mass resection: Bone margins of 1–2 cm should be the goal of excision



Surgical Treatment

- Closure will vary depending on the size and location of the resultant defect.
  - In many cases → preserved temporalis fascia
  - Extensive resection → polymethylmethacrylate (PMMA) prosthesis or titanium mesh
    - Advantages
      - ✓ Improved cosmesis
      - ✓ Increased protection of the exposed brain
    - Disadvantages
      - ✓ Cost, procedure time ↑
      - ✓ Increased risk of infection; empyema or removal

PMMA prosthesis

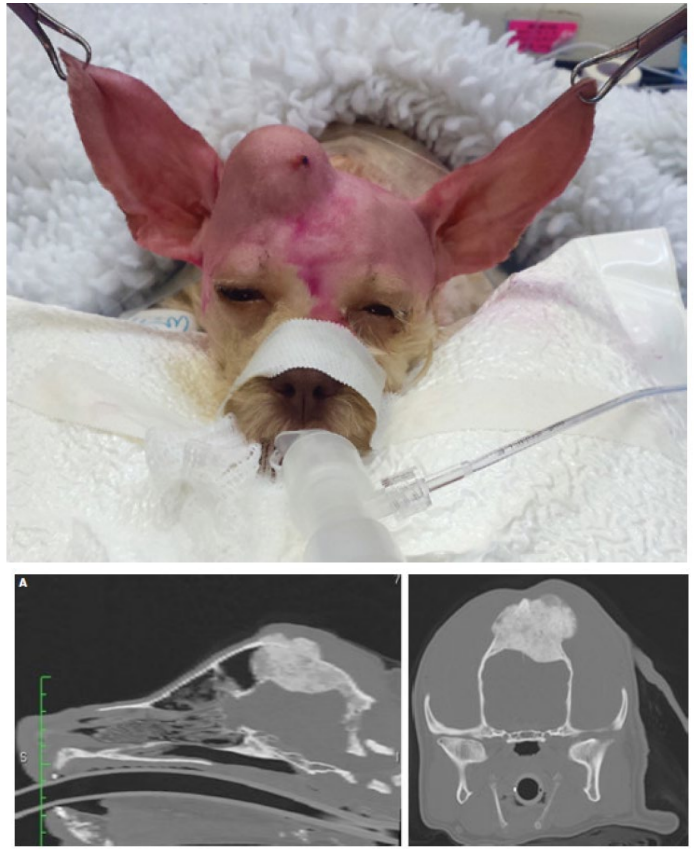


Titanium mesh

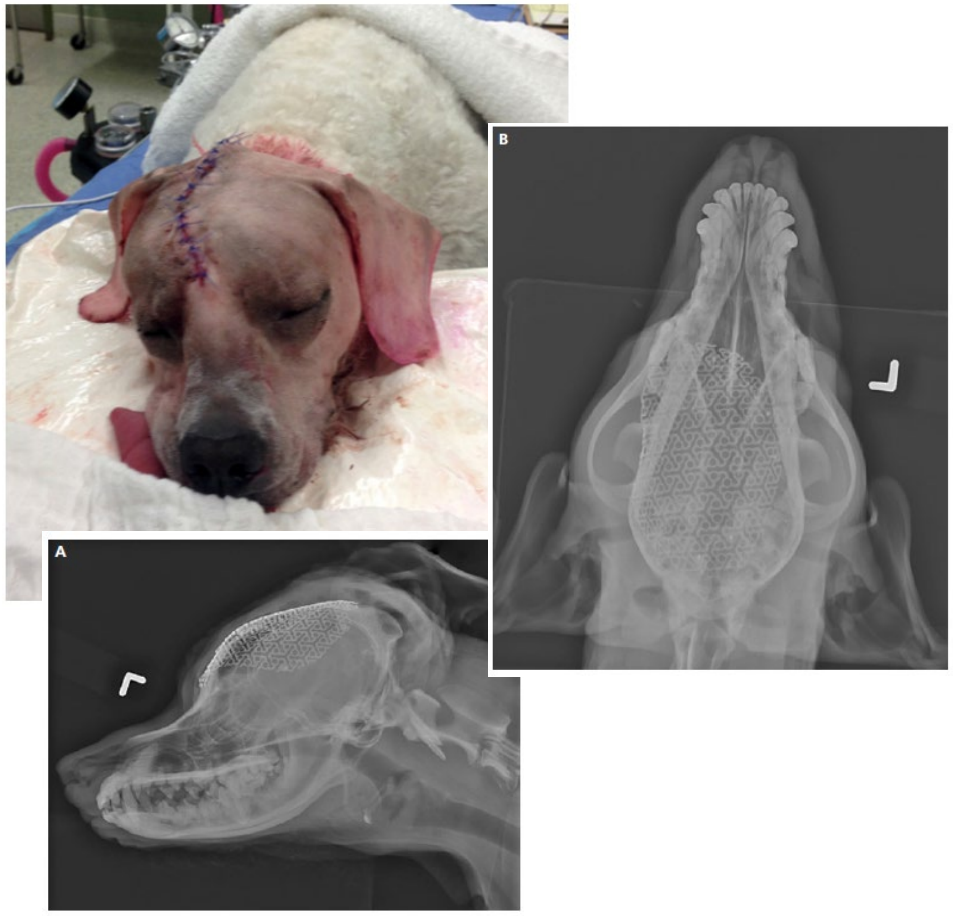
3D-printed titanium plate

Surgical Treatment

Pre-OP



Post-OP

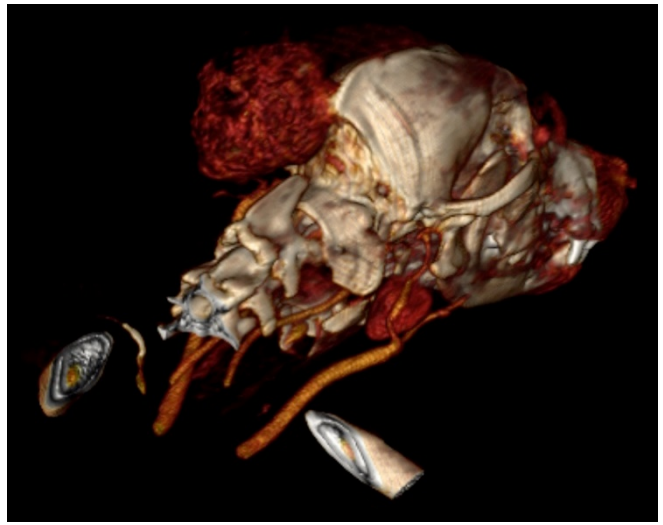


Protection helmet

Prognosis: Osteosarcoma (OSA)

- Dogs with completely excised tumors: MST > 1,500 days
- Dogs with incompletely excised tumors: approximately 250 days
- MST for dogs w/ surgically excised OSA: 329 days

  in 183 dogs w/ mandible, maxilla, and skull OSA
- The local recurrence rate: 51-80%
- The distant metastatic rate: 40%



Prognosis: Multilobular osteochondrosarcoma (MLO)

- Low histologic grade and complete excision → better prognosis
- Grade I MLO: the local recurrence rate is 30%, metastatic rate is 30%, and MST > 897 days

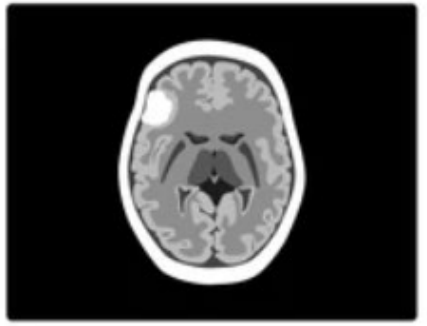
  > 50% of dogs are cured with surgery alone
- Grade II MLO: the local recurrence rate is 47%, metastatic rate is 60%, and MST 520 days.
- Grade III MLO: the local recurrence rate is 78%, metastatic rate is 78%, and MST 405 days

II. Brain tumor

- Extra-axial tumors

- arise from tissues outside the neural axis.
- most are peripherally located, cause inward displacement of brain parenchyma
- may be continuous with the falx or tentorium.

e.g. meningiomas, pituitary tumors, and intracranially invading nasal masses

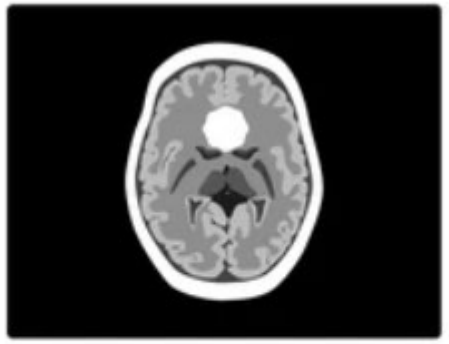


Extra-axial

- Intra-axial tumors

- radiate outward from a source within the neural axis
- even if peripherally located, cause a widening or spreading of brain parenchyma.

e.g. tumors of glial cell origin (astrocytoma, oligodendroglioma, ependymoma, choroid plexus papilloma, and medulloblastoma)



Intra-axial

II. Brain tumor

- Primary intracranial neoplasia represents 2~5% of all cancers, generally occurring in middle aged to older dogs and cats.
- Dogs) meningioma (50%), glioma(~35%), and choroid plexus tumors(~7%)
- Cats) meningioma (85%)

- MST in dogs with palliatively treated brain tumors is generally poor at 69 days.
  - ✓ Dogs with infratentorial tumors have a significantly shorter MST than dogs with supratentorial tumors at 28 versus 178 days, respectively.

Meningioma: Diagnosis

- Tumors typically have distinct and sharp margins
  - isointense or hypointense and homogeneous on T1W,
  - hyperintense and heterogeneous on T2W
  - moderate to marked post-contrast enhancement
- Some meningiomas have a dural tail sign, ring enhancement, and peritumoral edema, but these are nonspecific features and can be observed in other CNS lesions.

- Canine meningioma graded based on histological classification
  - Benign (grade I), atypical (grade II), anaplastic or malignant (grade III)

33.3% 59.5% 7.2%

Treatment: Surgical goals

- By removing as much of the tumour as possible during surgery, the remaining cells may become more 'sensitive' to radiation.
- The polytherapy approach (combination of medication, surgery and radiation) is the mainstay of treatment for most brain tumours in man.
- As a rough guide, average remission time ranges from 1 to 6 months with corticosteroids alone, from 8 to 14 months with radiotherapy alone, and 12 to 20 months with surgery followed by radiotherapy.

➔ The aim of treatment is to remove the bulk of the tumour by surgery to give other therapies a better chance of success. Surgery also allows the vet to obtain a sample of the mass and identify its nature

Treatment: Surgical indication

- Clinical symptoms, locations, consistency, hyperostosis, invasion to nerves and vessels etc.

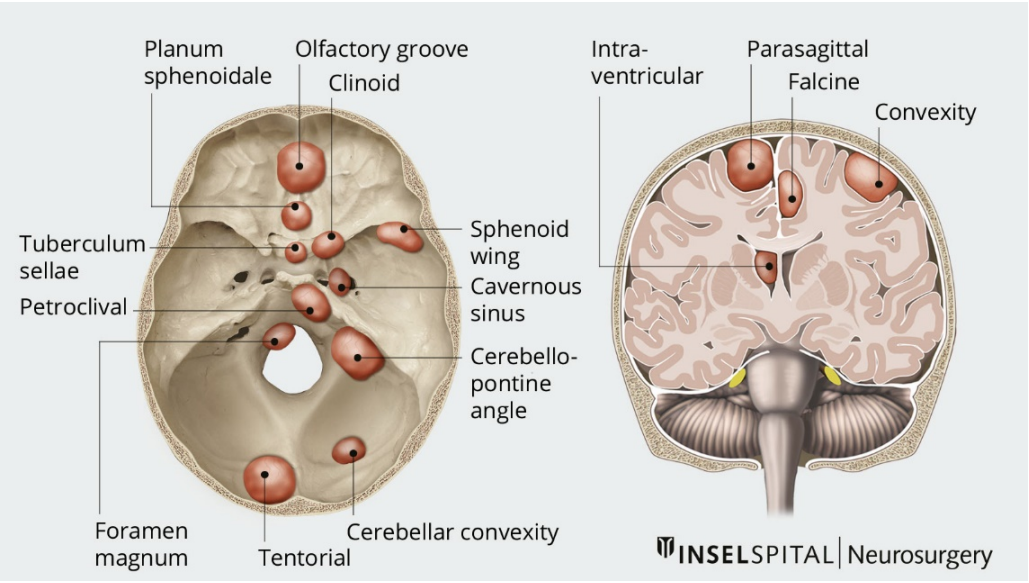
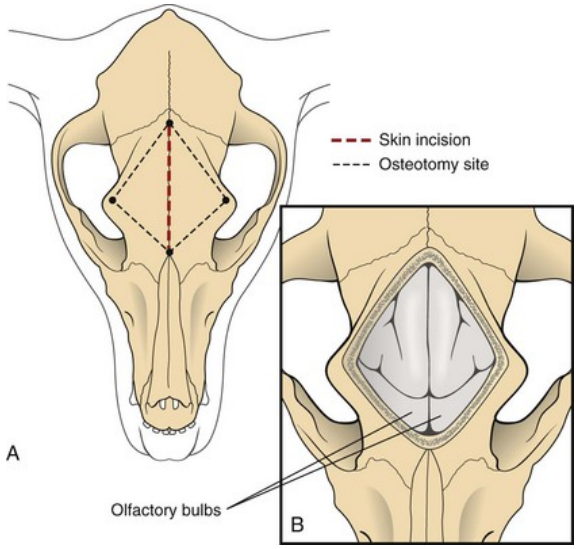


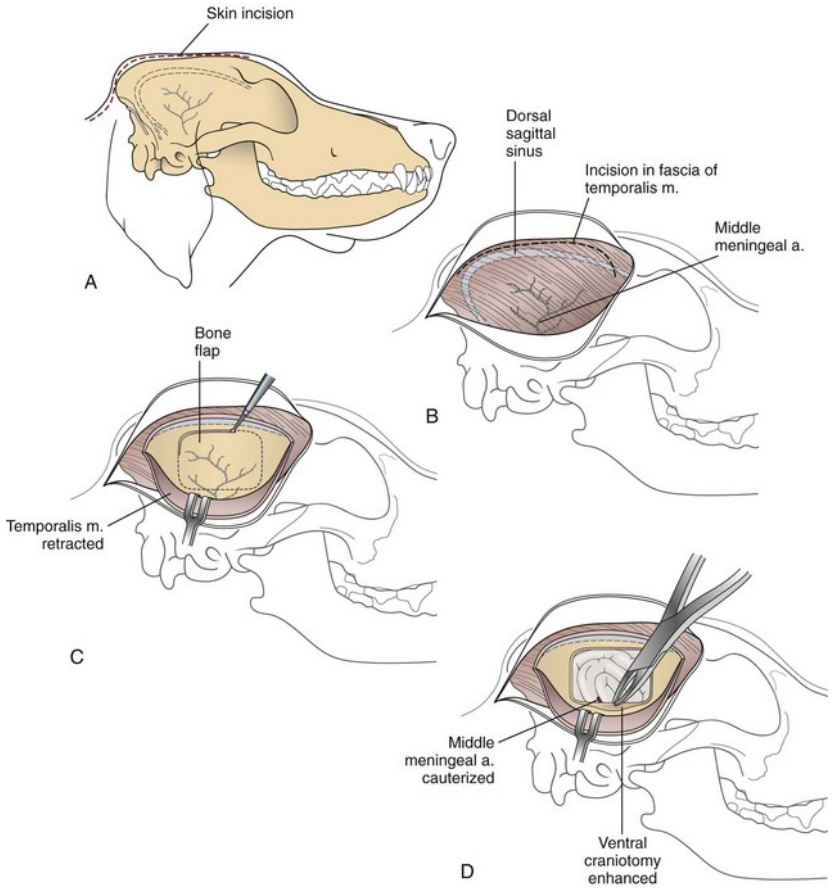
Table 22.1 Main approaches to the cranial vault for the extirpation of meningiomas in dogs and cats [4, 12, 13].

Approach	Indications	Modifications
Transfrontal craniotomy	Meningiomas ventral to frontal nasal sinus *Olfactory bulbs; rostral frontal lobe Rostral falx cerebri*	1. Purdue diamond
Rostrotentorial (lateral) craniotomy/ craniectomy	Convexity meningiomas and parasagittal meningiomas *Parietal, temporal, caudal frontal lobes Middle – caudal falx cerebri*	1. Combined with transfrontal 2. Split temporalis muscle (to access skullbase) 3. Transzygomatic (see Chapter 25)
Bilateral rostrotentorial craniotomy	Falcine meningiomas that have occluded DSS flow *Middle – caudal falx cerebri*	
Suboccipital craniectomy	Caudal cerebellar meningiomas (see Chapter 24)	1. Combine with C1 laminectomy
Transsphenoidal hypophysectomy	Pituitary fossa meningiomas (see Chapter 20)	

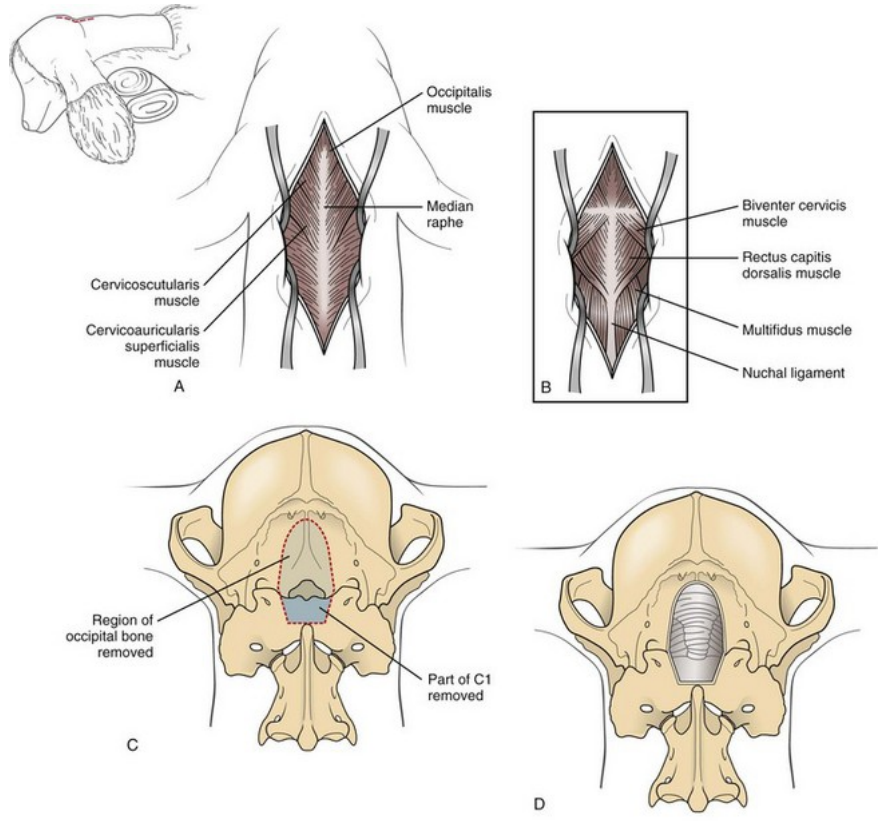
Treatment: Surgery



Transfrontal craniotomy

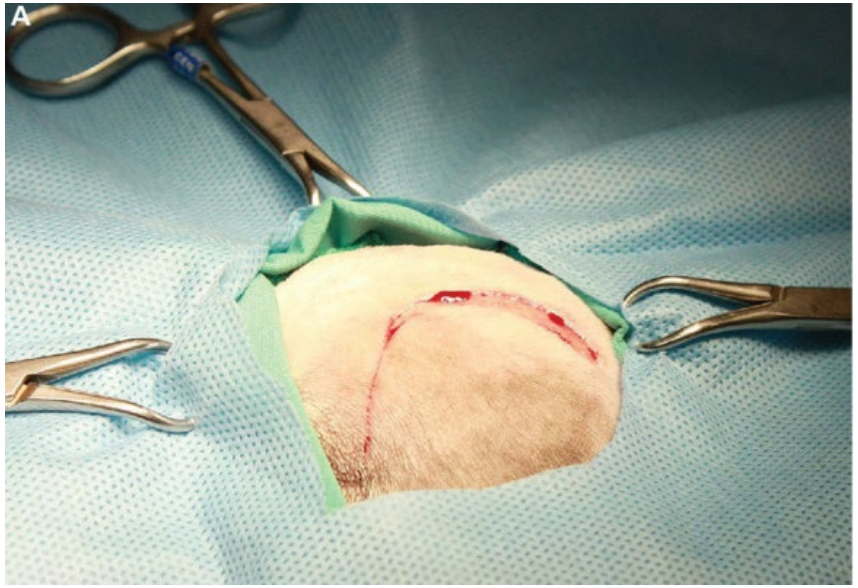


Rostrotentorial craniotomy



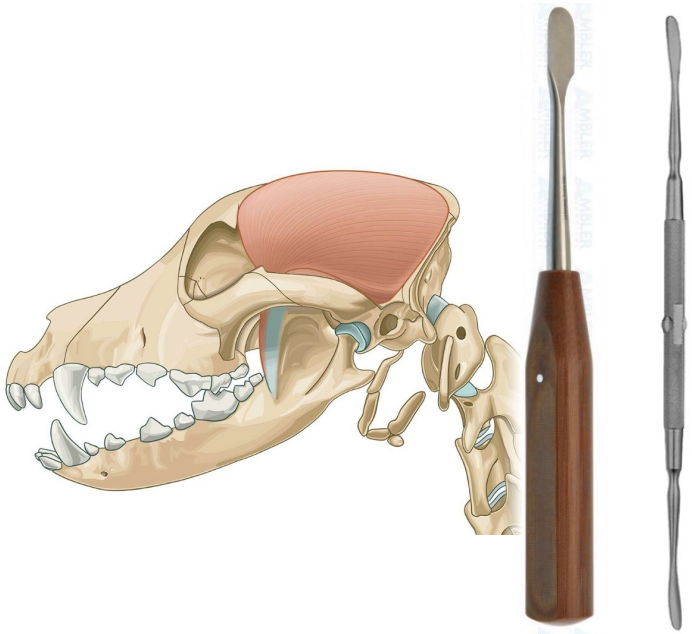
Suboccipital craniotomy

Treatment: Surgery



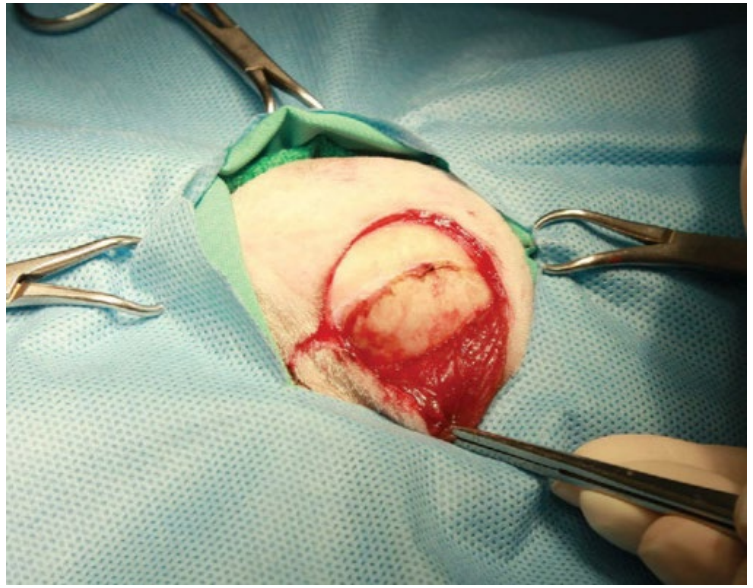
1. Skin & subcutaneous incision

※ Rostral: auriculopalpebral n.



2. Temporalis m. elevation

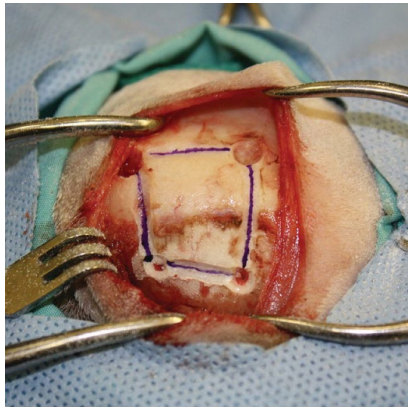
※ 2-4 mm to skull attachment



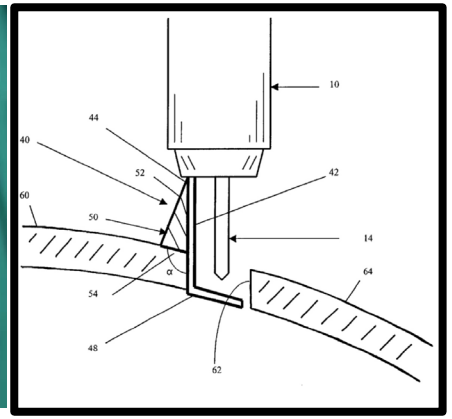
3. Temporalis m. reflection

※ Kept moistened

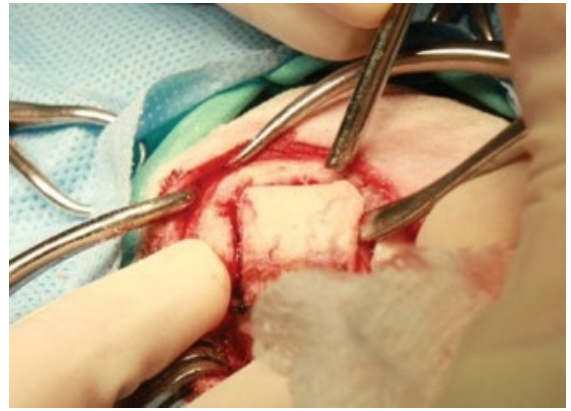
Treatment: Surgery



4. Making burr holes
   - Perforator
   - High-speed drill



5. Connecting burr holes
   - Craniontome (+dura guard)
   - High-speed drill
     - Ventral groove & elevation



6. Bone flap removal

Treatment: Surgery

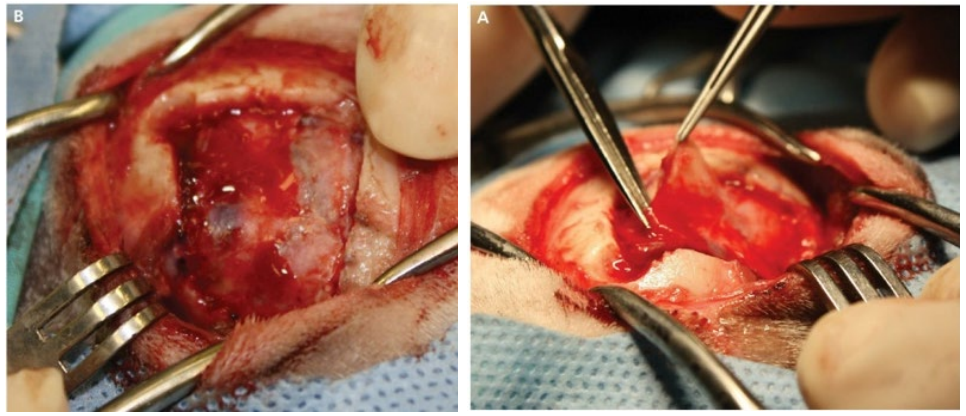
Brain navigator

- CT와 MRI 촬영 이미지를 동기화하여 두개골 및 뇌 실질 내 병변부의 해부학적 위치를 표현해주는 장치로 뇌신경 수술의 정확도와 안전성을 높임.
- 뇌종양 수술 시 정확한 위치와 깊이의 파악을 통해 최소한의 절개, 정확한 접근 진행 가능하고, 뇌수두증 치료에서 뇌실쪽으로의 VP shunt 삽입 위치 및 각도, 깊이 측정에 용이함.

CUSA (Cavitron Ultrasonic Surgical Aspirator)

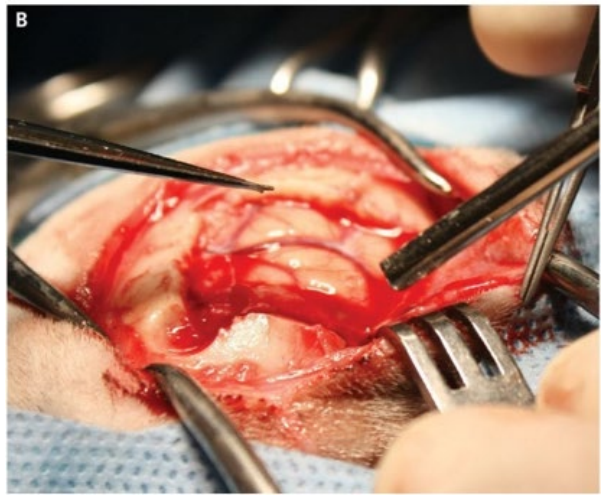
- 수술 중 기기의 끝부분에서 초음파로 인한 공명 현상(cavitation)을 통해 수분 함유량이 많은 종양 조직만을 절편화하여 흡인 및 제거가 가능한 기구
- 콜라겐이 풍부한 혈관, 신경(뇌 실질 및 척수), 요관 등은 손상시키지 않아 종양 조직만을 선별적 제거함.
- 뇌 실질과 인접하게 존재하는 종양 및 깊숙한 위치에 존재하여 시야가 불분명한 종양의 제거 시 뇌 실질의 보존에 용이함

Treatment: Surgery



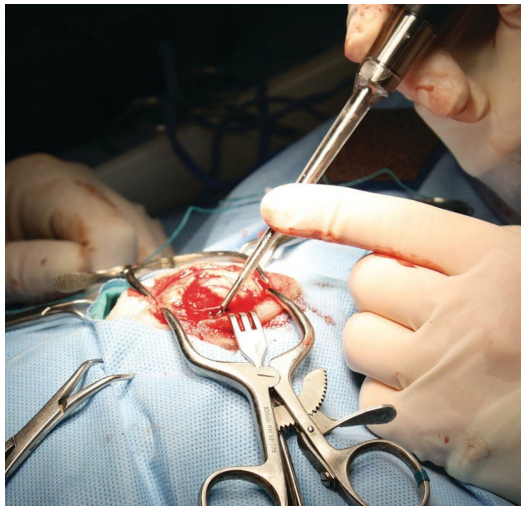
7. Dura exposure & incision

- Initial opening with # 12 blade
- Dural flap

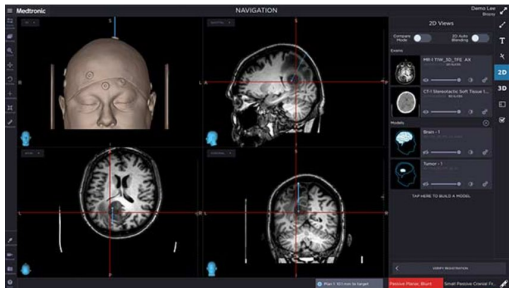


8. Cortical tissue exposure

- Approach to lesion
- To visualize lesions (▼)



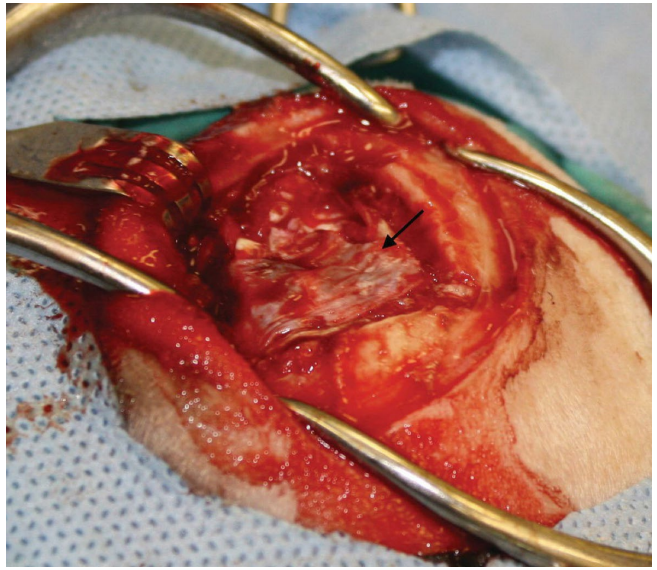
9. Mass removal/ debulking



Brain navigator

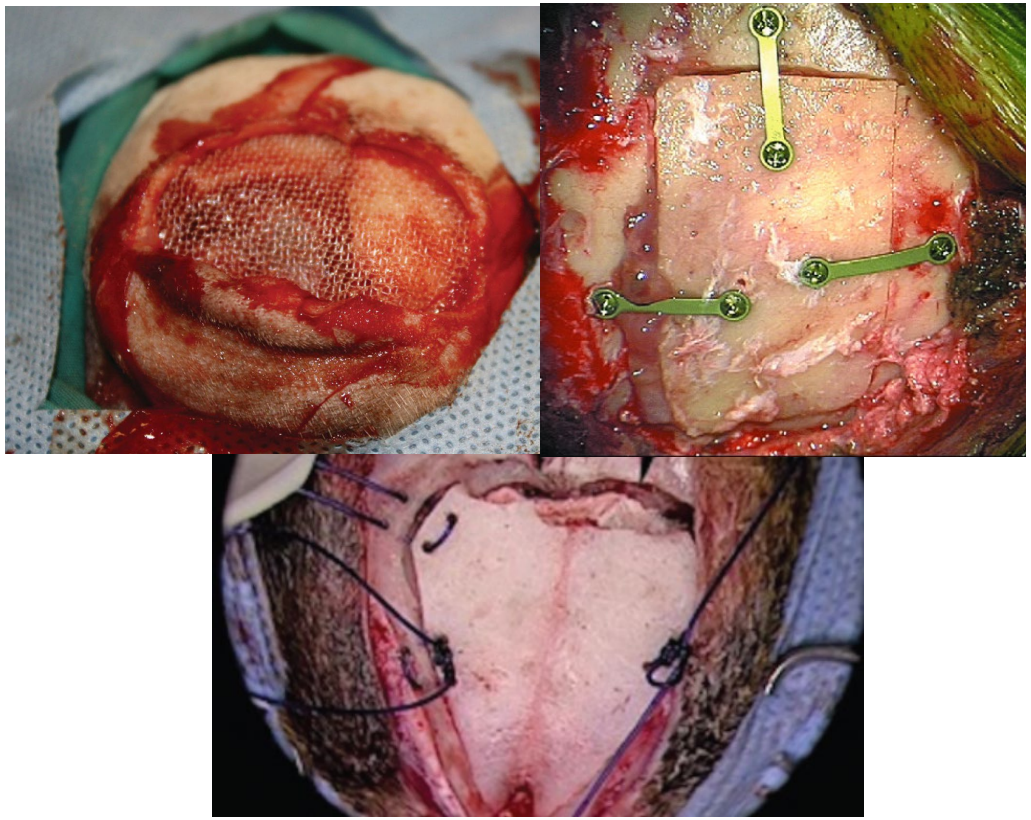
CUSA (Cavitron Ultrasonic Surgical Aspirator)

Treatment: Surgery



10. Dural covering

- Dura: often torn, can contain neoplastic cells
- Dural substitute and sealing
  : Temporalis m. fascia or commercial products



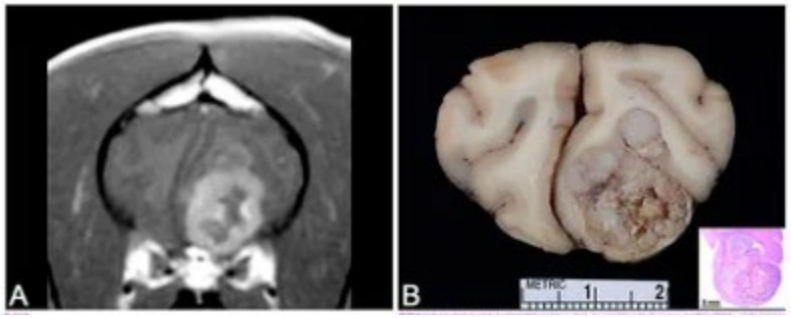
11. Bone defect covering

- Bone flap
- Polypropylene or titanium mesh
- Temporalis muscle

Prognosis – Canine Meningioma

- The MST for all dogs that underwent intracranial surgery for the resection of a meningioma was 353 days (218-485).

→ The higher incidence of atypical (grade II) meningiomas + their more invasive nature might account for poorer therapeutic response in dogs when compared to humans and cats.



- Dogs w/ surgery alone : MST 7 months, 19% survived > 1 year
- Dogs w/ Surgery + RT: MST 16.5 months, 53% survived > 1 year

➔ Because of this, additional adjunctive therapies are often used following the surgical excision of meningiomas in dogs in order to try and augment their survival time.

Prognosis – Canine Meningioma

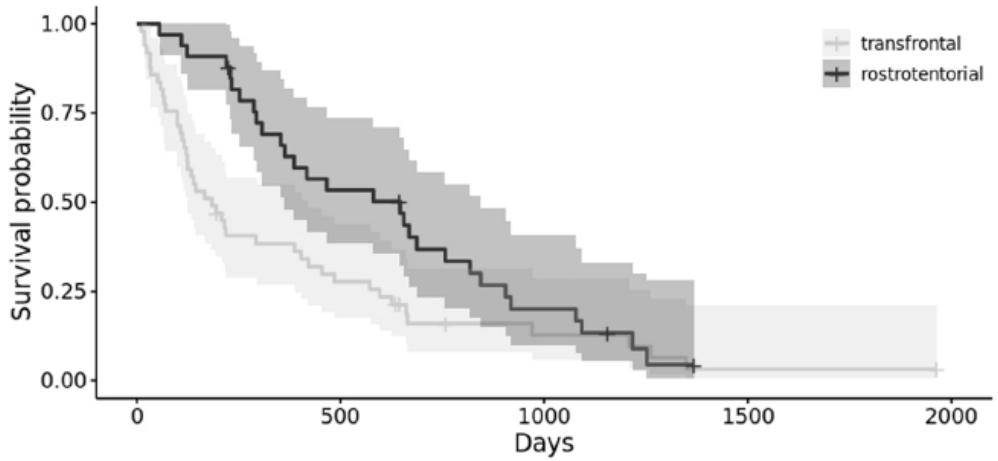
Table 2 The median survival time of dogs following discharge from hospital depending on the adjunctive therapy utilised and the surgical approach

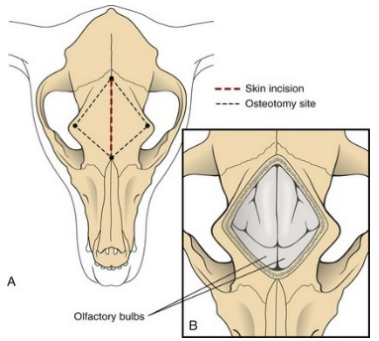
Adjunctive therapy				*Number of dogs*	*Median survival time (days)*	95% Confidence Interval	
Ultrasonic aspirator	*Hydroxyurea*	*Radiotherapy*	*Topical Chemotherapy*			*Lower Bound*	*Upper bound*
*	*	*	*	1	1079	–	–
*		*		2	918	–	–
	*			6	626	121.9	1130.1
*				18	421	155.9	686.1
	*	*		2	417	–	–
				21	353	246.8	459.2
*	*			17	293	0.0	801.9
		*		4	232	87.0	377.0
*	*		*	10	166	0.0	558.0
	*		*	3	144	84.8	203.2
*			*	3	99	0	206.2
Surgical approach							
Sub-occipital				5	898	336.5	1459.5
Rostrotentorial				33	646	327.4	964.6
Transfrontal				49	184	90.2	277.8
Total number of dogs				87	386	271.4	500.6

Legend: * indicates the utilisation of that particular adjunctive therapy

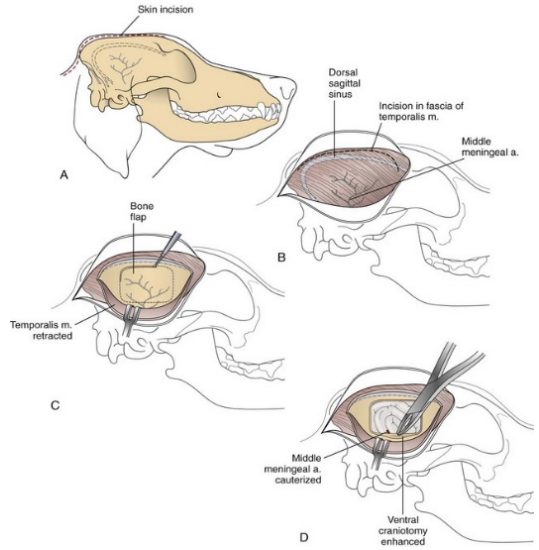
Prognosis – Canine Meningioma

- MST associated with the surgical approach
  - Transfrontal approach:184 days / rostrotentorial approach: 646 days



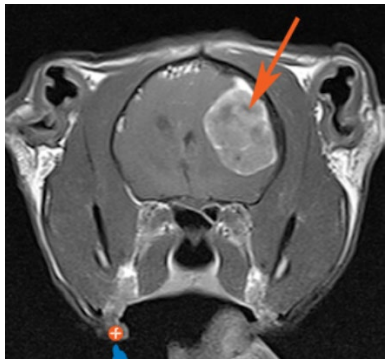


Transfrontal craniotomy



Rostrotentorial craniotomy

Prognosis – Feline Meningioma

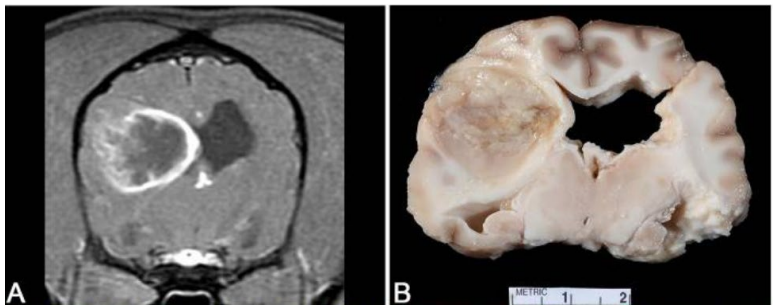


- Cats have a MST of about 3 years with no additional intervention such as chemotherapy or radiation therapy.
  - ✓ In cats, we often think of the surgical excision of an intracranial meningioma as curative, with a reported MST of 37 months and the majority of cats eventually dying of causes unrelated to the meningioma.
- Unlike dogs, meningiomas in cats are often better defined and less invasive, and hence further adjunctive therapy following their excision is not typically necessary.
- MST w/ RT: 339 days, MST w/ Surgery: 1345 days (Tichenor et al. 2023)

Glioma

- Glioma continues to be a common brain tumor diagnosis in the dog, especially brachycephalic dogs (> 50%). Feline glioma is a less well-described condition.
- A large proportion of dogs present with an acute onset of seizures and almost half present with cluster seizures or status epilepticus as the initial onset.
- Glioma can be challenging to distinguish from other neurologic lesions.
- MRI findings correlate better with tumor grade than tumor type,

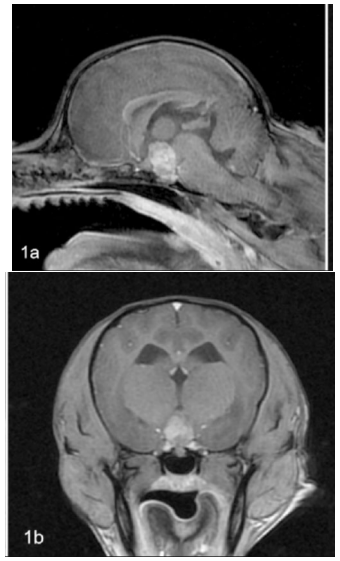
  - with contrast enhancement, gradient echo signal voids, and T2W-heterogeneity all increasing with increasing grade.



Glioma - Prognosis

- MST for dogs with glioma treated palliatively: 26-60 days
- Surgical resection alone for treatment of glioma has the same MST as with palliative therapy, suggesting that definitive treatment of glioma requires multimodal therapy
- Despite marked variability in treatment modalities (surgery, radiotherapy, chemotherapy), MST for definitively treated cases (n = 23) was longer (84 days) than for palliative treatment cases (n = 22; 26 days)
- With surgery alone: MST 2-6 months. With RT used alone: with reported MST of 7-28 months
- No published data of post-OP RT MST
- When SRT is incorporated into the management plan for dogs with confirmed or presumed intracranial glioma, a median survival time of approximately 12 months may be achievable.

Pituitary tumor – Surgical indication



- ✓ Pituitary-dependent dependent hyperdrenocorticism (PDH) in dogs and cats
- ✓ Hypersomatotropism (HST) in cats
- ✓ Clinical, non functional sellar tumors in dogs and cats

- Case selection for hypophysectomy is dependent on clinical signs, endocrine testing, tumor size, and concurrent co-morbidities in a given patient.

- Candidates for TSH

- Dogs diagnosed with PDH, showing endocrine signs, and w/ or w/o a definable pituitary mass based on brain imaging who failed medical management.
- Cats diagnosed with HST w/o significant co-morbidities

Pituitary tumor – Surgical indication

Tumor size does play a role in the successful outcome after surgery and potential long-term complications

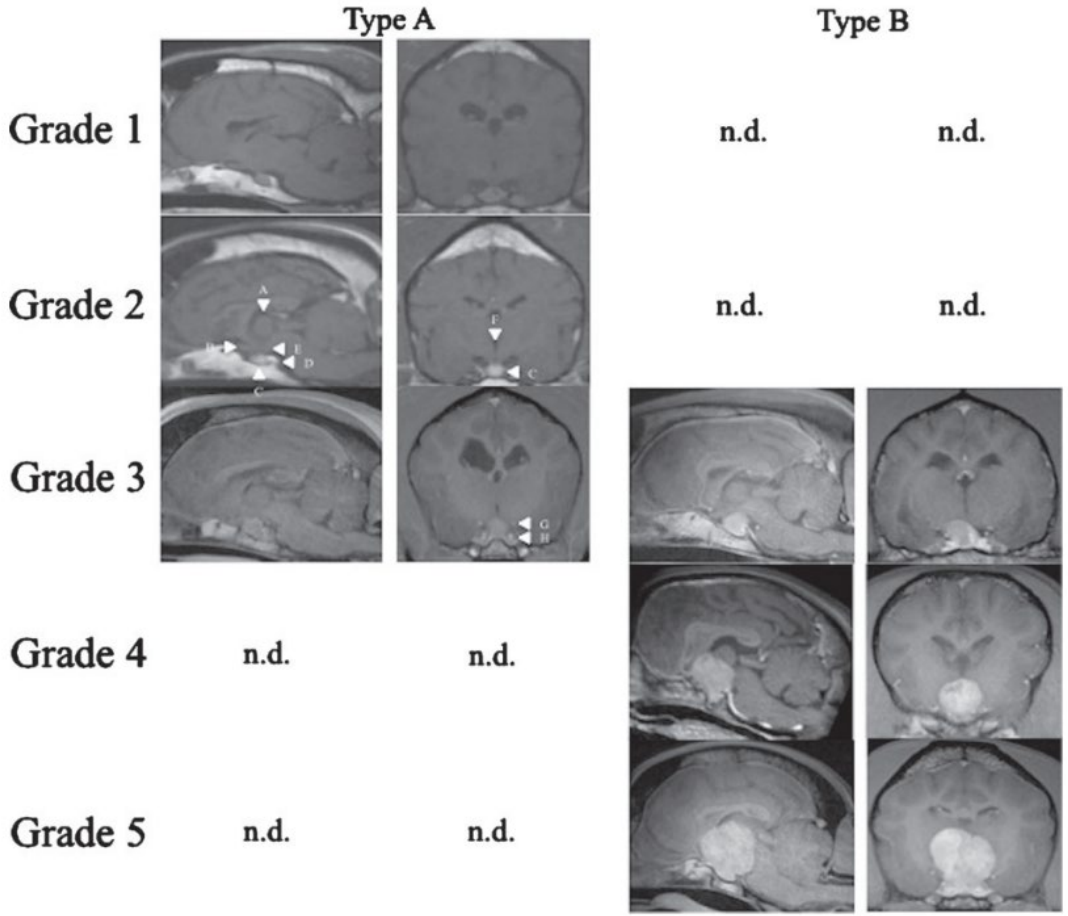


Table 1. Magnetic resonance imaging-based pituitary gland classification system in dogs with hyperadrenocorticism

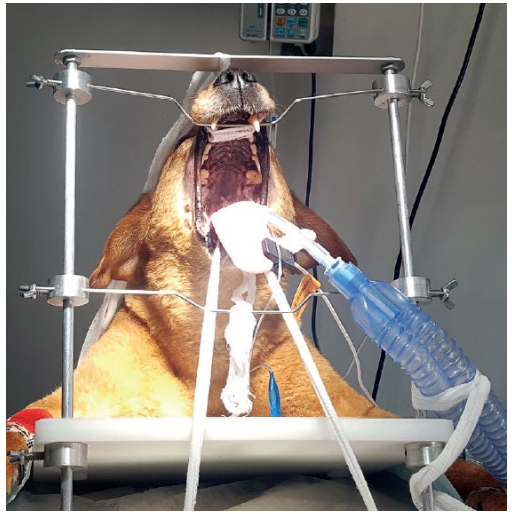
	Extending beyond the dorsum sellae and up to the third ventricle	Touching the optic chiasm and/or mammillary body	Touching the interthalamic adhesion	Occupation of the third ventricle	Involvement of the arterial circle of Willis or the cavernous sinus	
					–	+
Grade 1	–	–	–	–	Type A	Type B
Grade 2	+	–	–	–		
Grade 3	+	+	–	–		
Grade 4	+	+	+	–		
Grade 5	+	+	+	+		

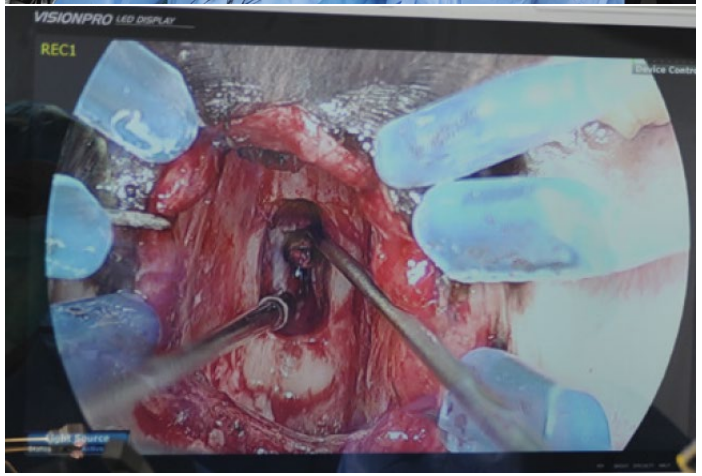
ACTH adrenocorticotropic hormone

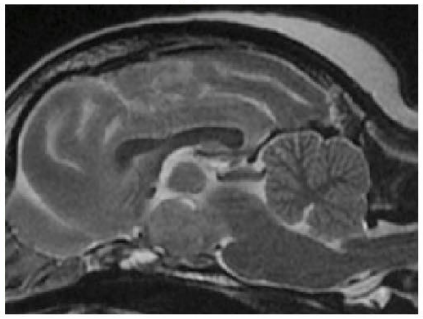
Sato et al. determined that dogs with functional pituitary tumors of type A, grade 1 to 3 had a good prognosis following TSH and that dogs with grade 3B, 4 and 5 may not be suitable for TSH. Sato et al. considered these dogs unsuitable because only partial resection could be expected without radical cure. Although this was devel-

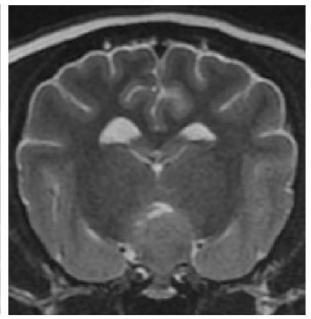
종괴 크기, 인접한 조직, 혈관 침습 정도
Grade 1-3A: 수술적 예후 양호
Grade 3B-5: 수술 단독으로는 예후 안좋을수 있음

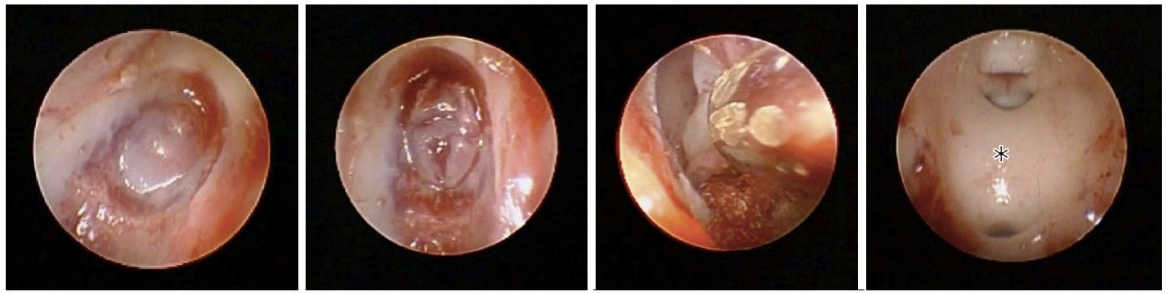
Pituitary tumor – Surgical treatment

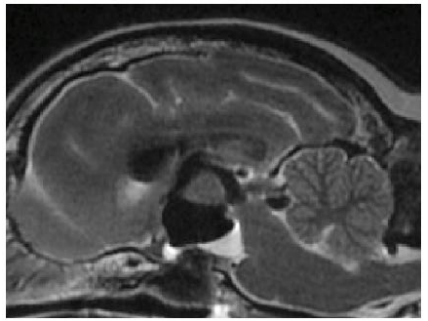


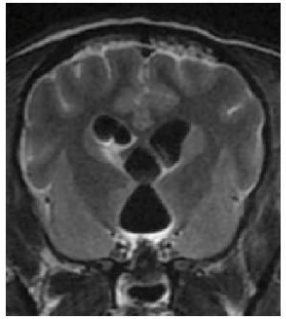


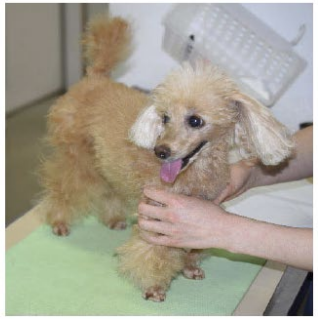












Pituitary tumor - Prognosis

J Vet Intern Med 2015;29:1456–1463

Systematic Review of Brain Tumor Treatment in Dogs

H. Hu, A. Barker, T. Harcourt-Brown, and N. Jeffery

Table 3. Median survival time of dogs with masses at specific locations

Tumor Location	Number of Studies (Total Cases)	Median Survival Time (Range of Medians) in Days
Extra-axial	17 (335)	348 (46–2104)
Intra-axial	10 (127)	226 (60–437)
Pituitary	6 (104)	351 (of those reaching median) (118–688[a])

[a]The study by Kent et al[35] reported a median survival of more than 2000 days.

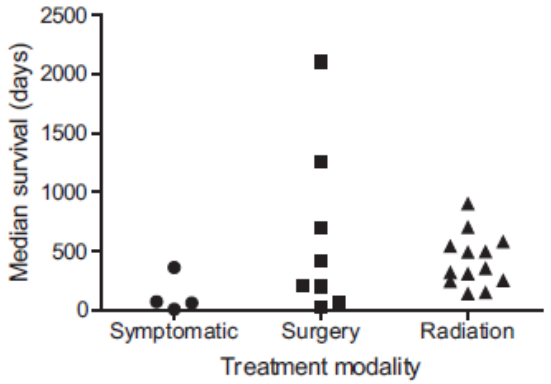


Fig 2. Median survival times associated with treatment using different modalities. This plot was compiled from data included in references.[10,11,20,24–28,30–40,45,46] The data included in references[31] and [32] have been subdivided into two points because the summary data was unavailable.

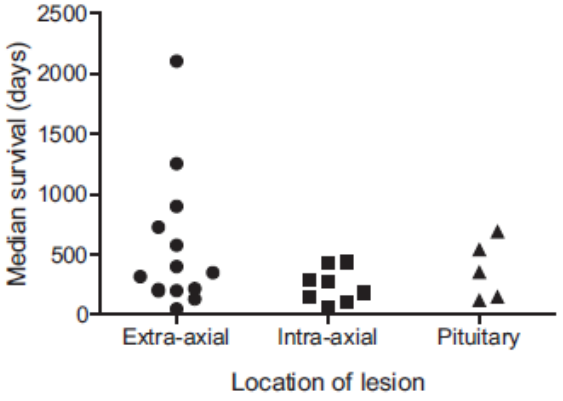


Fig 3. Median survival time associated with masses located at different sites within the skull. This plot was compiled from data included in references.[20,25–34,37–40,45] Reference[35] (Kent et al is not included here because the treated group did not have a median survival).

Pituitary tumor - Prognosis

- MST: RT vs. Untreated
  - RT: 1405 days (1053-1757)
  - Untreated: 359 days (48-916)

- MST: Medical vs. Med+RT
  - Medical: 143 days
  - Med+RT: 973 days

- MST: Surgical debulking+RT
  - Perioperative mortality: 33%
  - MST: 232 days (0-1658)
  - If discharged, MST 708 days

J Vet Intern Med 2007;21:1027–1033

Survival, Neurologic Response, and Prognostic Factors in Dogs with Pituitary Masses Treated with Radiation Therapy and Untreated Dogs

Presumed pituitary apoplexy in 26 dogs: Clinical findings, treatments, and outcomes

Christian W. Woelfel[1] | Christopher L. Mariani[2,3,4] | Michael W. Nolan[2,4] | Erin K. Keenihan[1,5] | Sophia P. Topulos[1] | Peter J. Early[2,4] | Karen R. Muñana[2,4] | Sarah E. Musulin[2] | Natasha J. Olby[2,4]

Clinical characteristics and outcome in 15 dogs treated with transsphenoidal hypophysectomy for nonfunctional sellar masses

Post-OP Complications

Incidence of and risk factors for major complications or death in dogs undergoing cytoreductive surgery for treatment of suspected primary intracranial masses

JAVMA | DEC 15, 2018 | VOL 253 | NO. 12

- 21 (13.1%) dogs died (11 during hospitalization and 10 after discharge) and 18.8%) developed major complications other than death during the first 30 days after surgery.
  - Dogs with abnormal preoperative neurologic examination findings were more likely to develop complications or die.

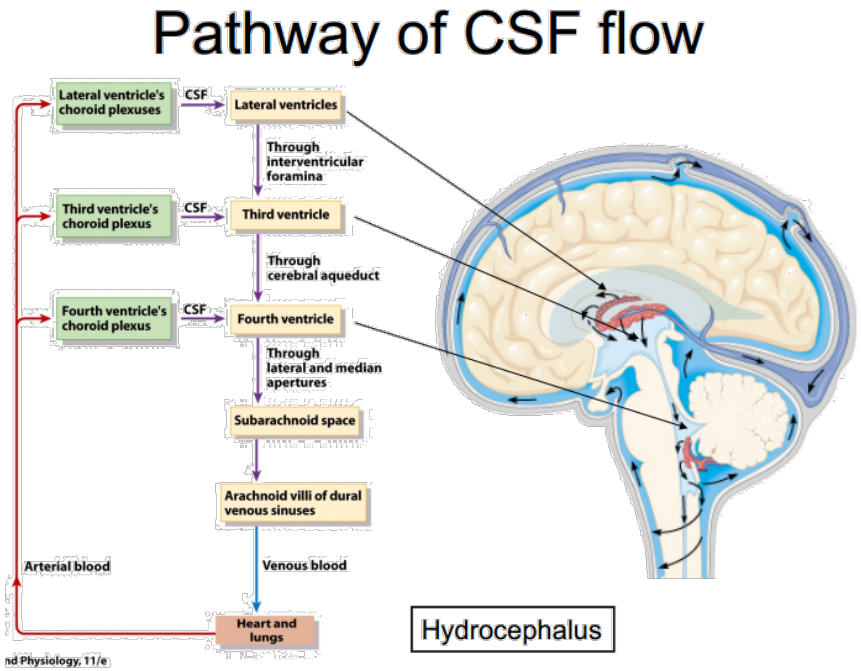
- Seizures (n = 18 [11.3%]), worsening of neurologic status (6 [3.8%]), and aspiration pneumonia (6 [3.8%])

III. Hydrocephalus

- Active distension of the ventricular system of the brain caused by obstruction of flow of CSF from production ~ absorption site

✓ Developmental abnormalities
✓ Acquired lesions e.g. neoplasia, inflammation

※ Hydrocephalus ex vacuo: not active
- infarction, necrosis → brain tissue loss



Medical therapy

- Acetazolamide, furosemide, or omeprazole / Glucocorticoids (PDS)
- Used to delay surgery, to magage acute dterioration
- When surgery is not an option or not indicated

Surgical treatment

- Surgical procedure to divert CSF
- Ventriculoperitoneal shunt, Endoscopic 3rd ventriculostomy

III. Hydrocephalus

비엔동물전문의료센터
BIEN ANIMAL MEDICAL CENTER

Pediatric hydrocephalus

Toy & brachycephalic dogs: risk ↑

- Caused by developmental abnormalities
  - ✓ Obstruction at the level of the subarachnoid space or arachnoid villi
- Clinical signs are usually apparent by several months of age
  - ✓ Blindness, ataxia, circling, strabismus
- May associated with other malformations
  - Meningomyelocele, Chiari-like malformation, Dandy-Walker syndrome, arachnoid diverticula

Acquired hydrocephalus

- Can develop at any age due to tumors and inflammatory disease
- Malformation of the skull dose not develop if hydrocephalus develops later
- Neurological deficits are similar to those in young patients

Diagnosis

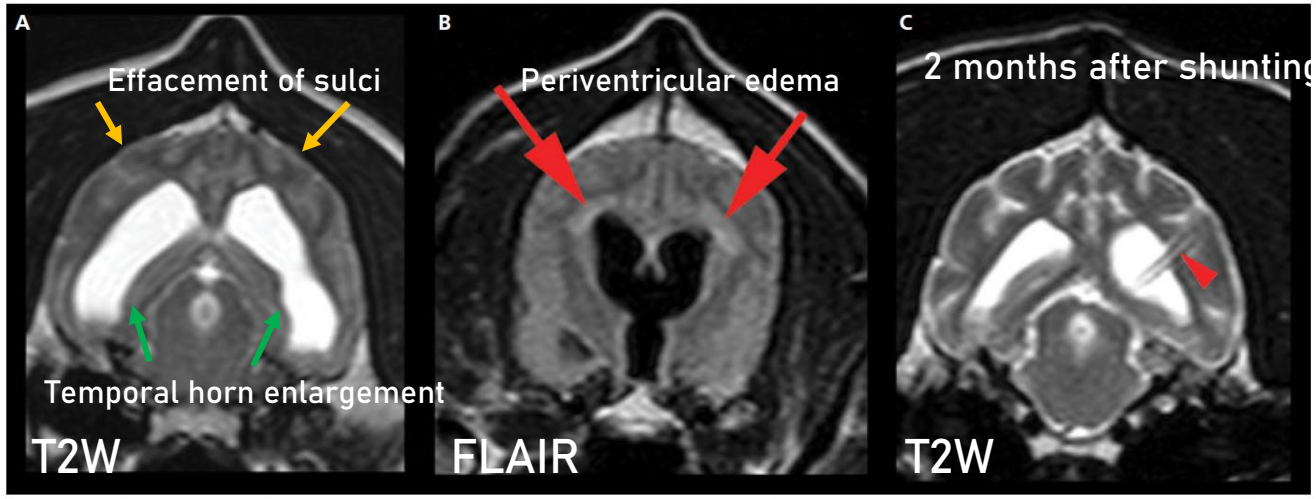
MRI — The best modality to assess ventricular size and other lesions

- ✓ Obstructing masses such as tumors, granulomas, and diverticula

CT — Follow-up of previously diagnosed patients and those with an existing shunt

U/S — Assesing ventricular size in patients with a persistent fontanelle

★ Evidence of increased intraventricular pressure



1) Periventricular edema
2) Enlargement of the temporal horns
3) Effacement of sulci

➔ Acute, active hydrocephalus

➔ Indication for treatment

Diagnosis

CSF collection Helpful in cases of suspected meningoencephalitis

- Imaging is performed first to identify any shifting of brain tissue e.g. caudal cerebellar herniation etc.

✓ Cerebellomedullary cistern

✓ Enlarged lateral ventricle through a persistent fontanelle

CSF removal Used as a temporary measure to decrease IVP & predict surgical shunting

- Ultrasound is helpful. 25G needle, inserted at the lateral aspect of the fontanelle

* Avoid the sagittal sinus on the midline

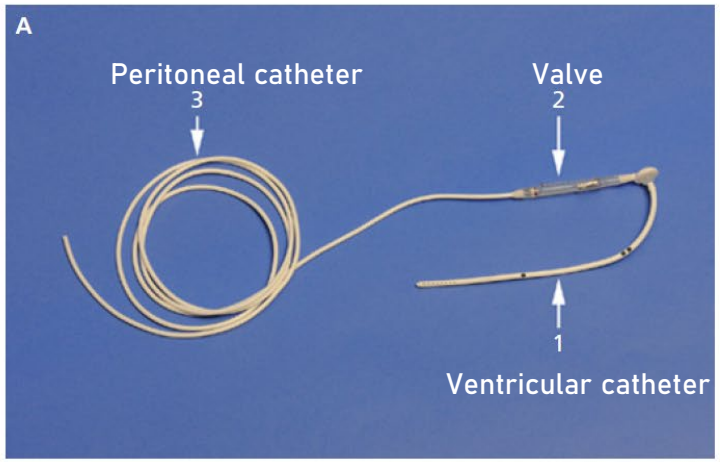
Indications for surgery

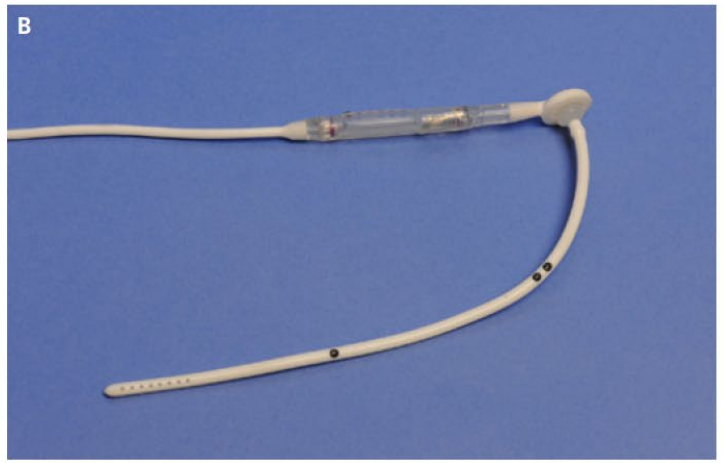
✓ A young patient with clinical signs, ventriculomegaly + evidence of increased intraventricular pressure

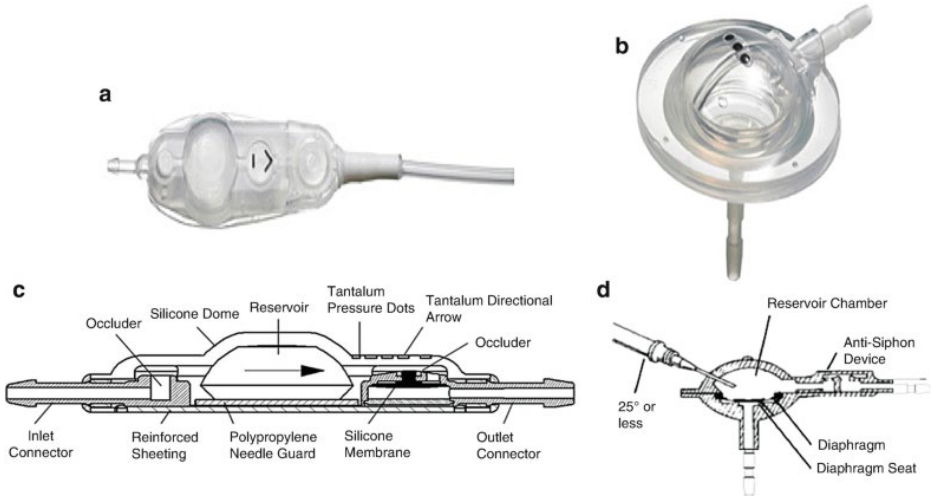
✓ Progressive ventriculomegaly over time

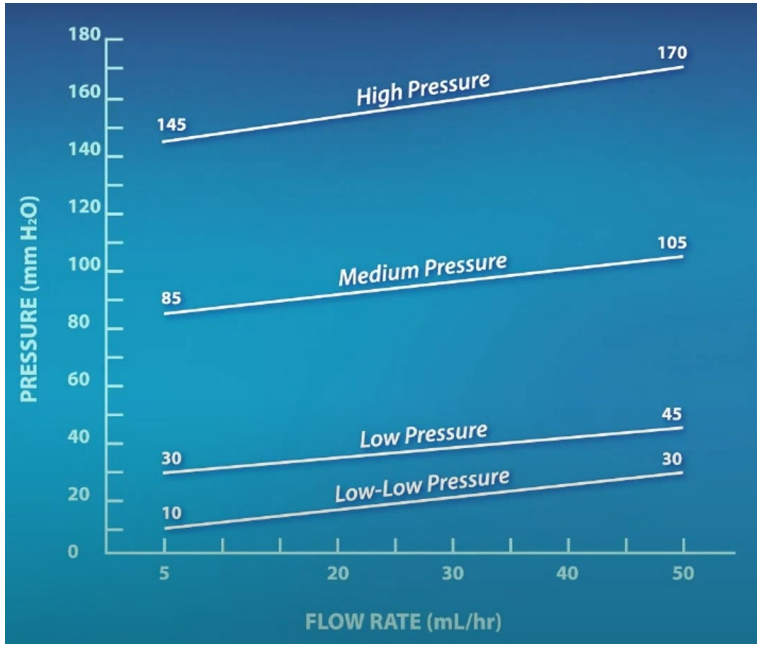
Surgical Treatment

Ventriculoperitoneal shunt (VP shunt)



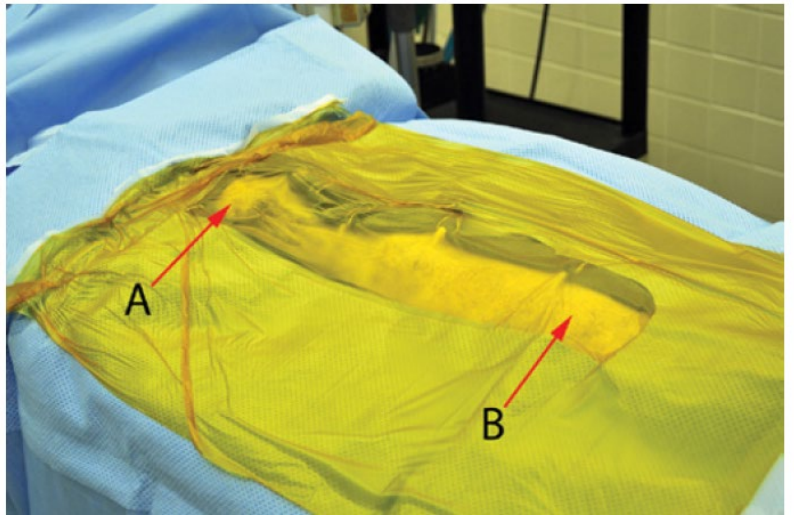


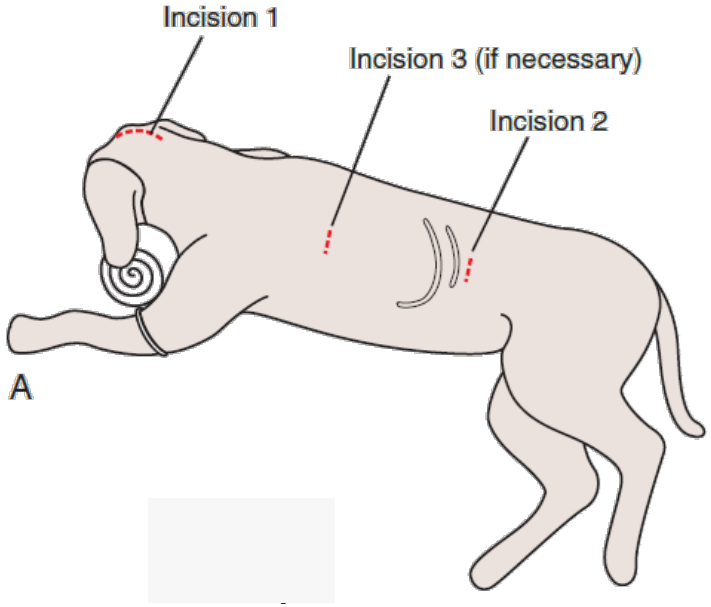




Surgical Treatment

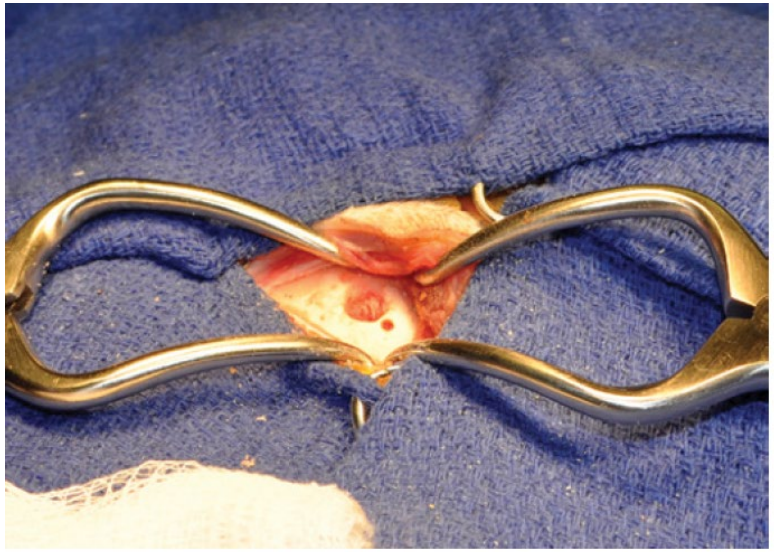
Preparation



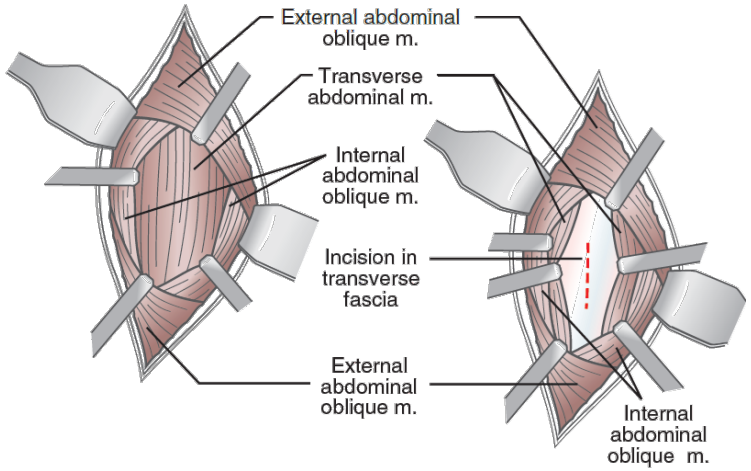


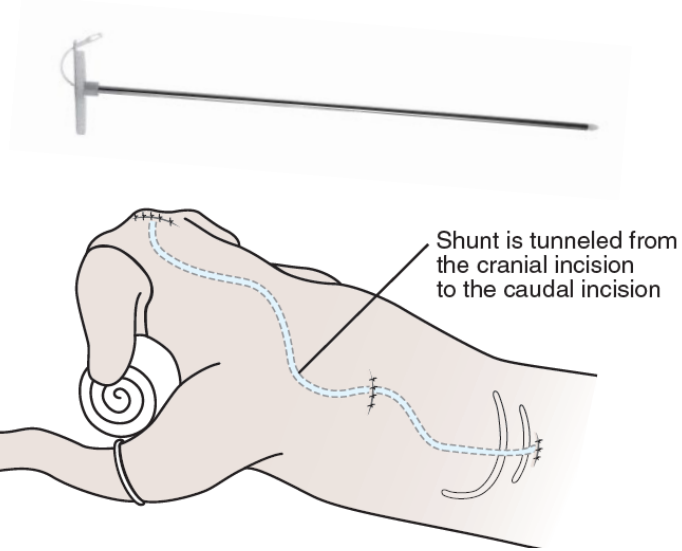
Surgical Treatment

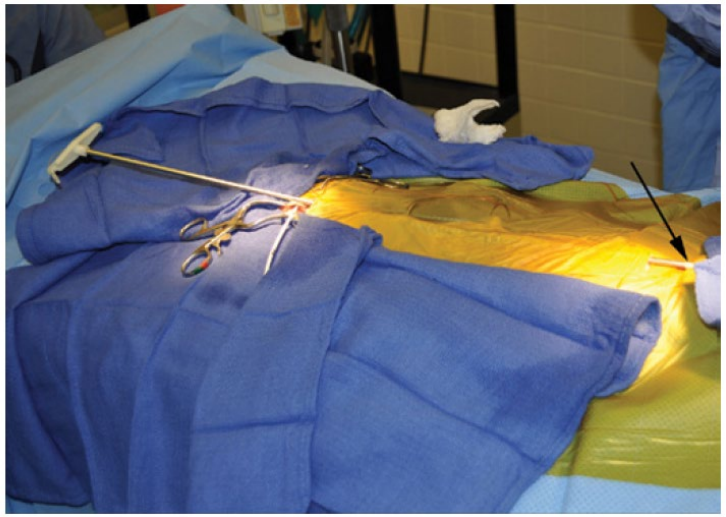
Cranial incison & burring



Abdominal incision



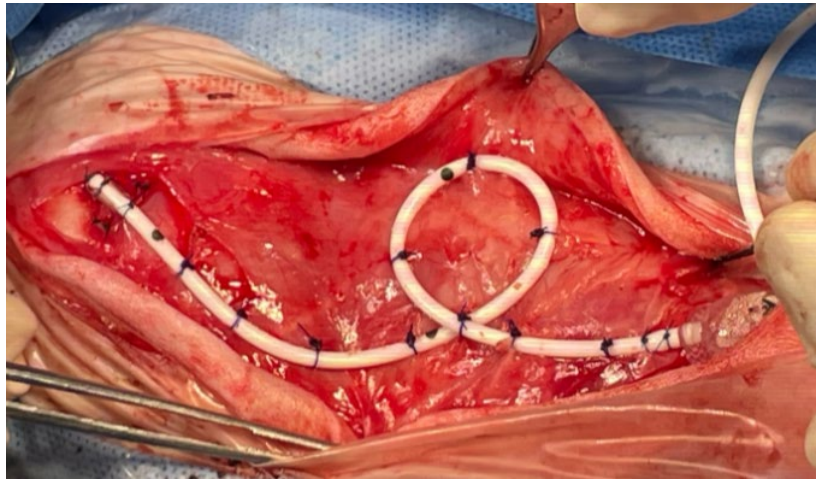


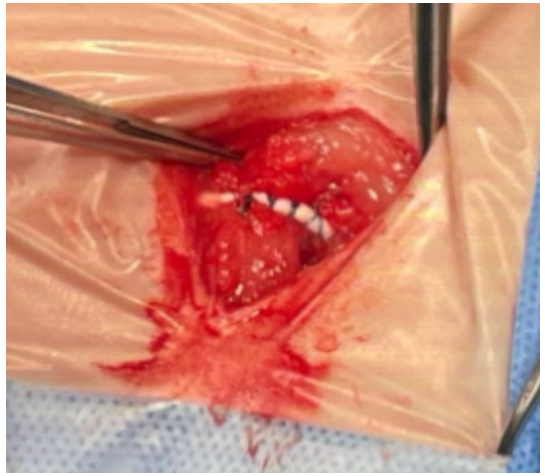


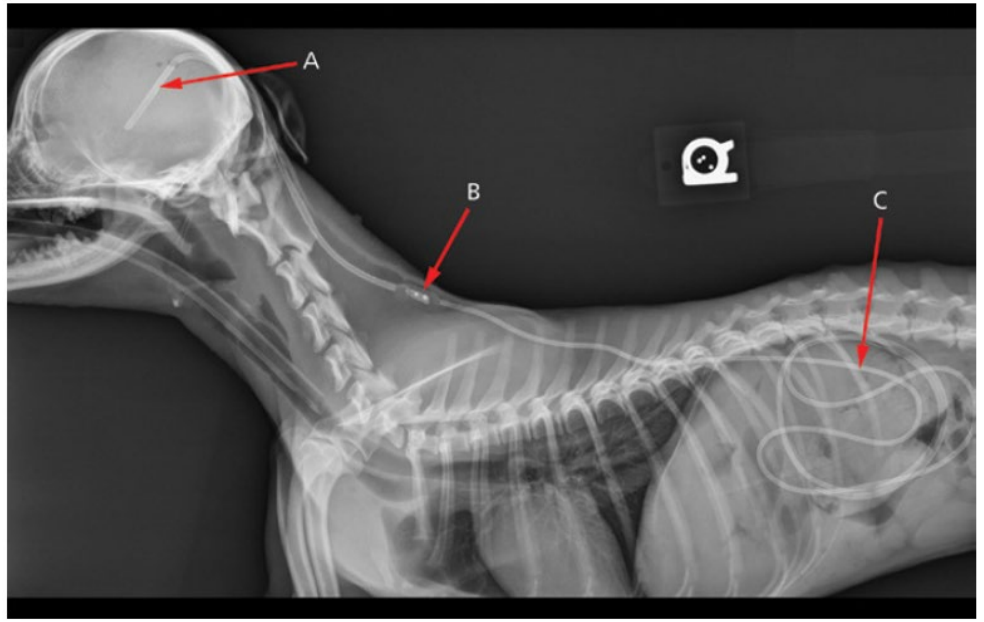
Connecting incision

Surgical Treatment

Shunt placement







Post-OP complications

Complications associated with ventriculoperitoneal shunts in dogs and cats with idiopathic hydrocephalus: A systematic review

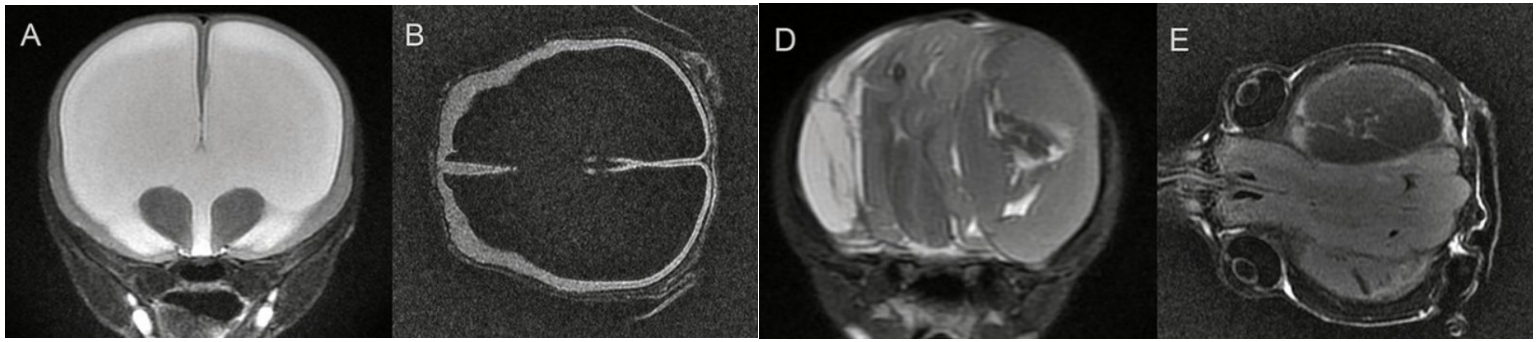
Journal of Veterinary Internal Medicine
J Vet Intern Med. 2019;33:403–412.

Gabriele Gradner | Rose Kaefinger | Gilles Dupré

<Complications>

- ✓ Obstruction (9.6%)
- ✓ Pain (5.6%)
- ✓ Infection (4.1%)
- ✓ Disconnection (4.1%)
- ✓ Overshunting (2.7%)
- ✓ Kinking (2.7%), Coiling
- ✓ Postoperative seizures
- ✓ Breakage (1.3%)
- ✓ Subdural hematoma (4.1%)

- Obstruction was the most common complication. (7/73; 9.6%)
- 10 animals died or were euthanized because of shunt-related complications (13.7%).
- The reasons for death or euthanasia were obstruction (4/7, 57%), infection (2/3; 66.7%), overshunting(2/2; 100%), disconnection (1/3; 33.33%), and pain (1/4; 25%).



➔ Complications are most likely to occur during the first 6 months after shunt placement.

Post-OP care

- Pain control: injectable analgesics → oral medication
- Antibiotics: occasionally continued for several days
- Preoperative antiseizure medications are continued as needed.
- Two-view radiographs of the entire shunt
- Neurological deficits usually resolve quickly
- Reassesment within the first 2-3 months with U/S, CT or MRI

Prognosis

- Post-OP clinical improvement rates: 72-100%.
- 72% of animals with congenital hydrocephalus had clinical improvement after shunt placement and 25% had resolution of clinical signs.
- Postoperative survival was 80% at 1 mo, 66% at 3 mo, and 55% at 18 mo.

IV. COMS (Caudal Occipital Malformation Syndrome)

- Chiari-like malformation (CM)

  : a complex developmental condition of the skull and craniocervical vertebrae

  : a conformational change and overcrowding of the brain and cervical spinal cord, particularly at the craniospinal junction.

- Obstruction to cerebrospinal fluid (CSF) channels

  → pain, fluid cavitation of the spinal cord, called syringomyelia (SM)

  → these fluid pockets can cause irreversible damage to the spinal cord, resulting in clinical signs of pain and neurological deficits.

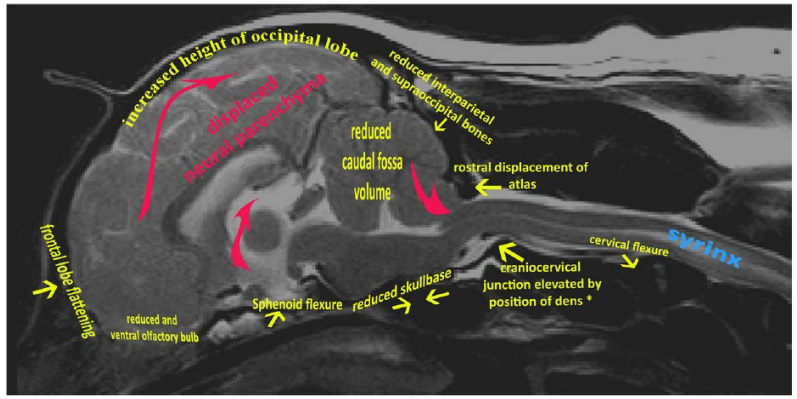
TABLE 1 Clinical Signs of Chiari-like Malformation and Syringomyelia in Dogs

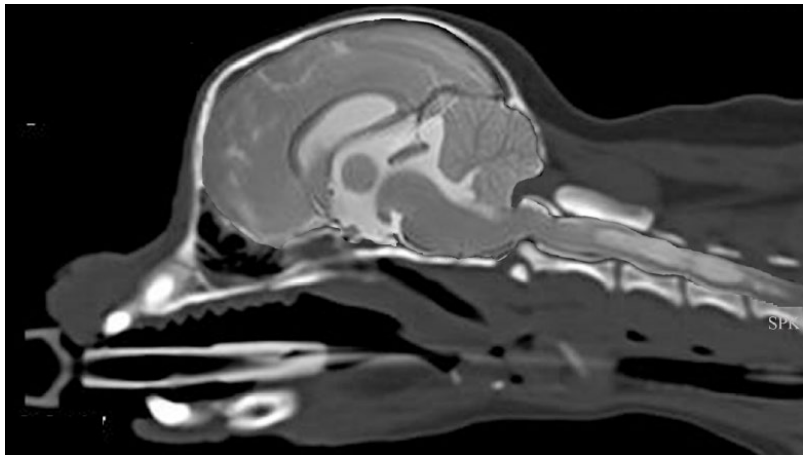
COMMON	LESS COMMON
Spontaneous yelping	Seizures
Phantom scratching	Tail chasing
Pain upon palpation of neck	Air licking
Facial pruritus/rubbing	Paw licking
Pain when picked up	Proprioceptive deficits
Irritation with collar/harness	Lethargy
	Reluctance to jump
	Vestibular dysfunction
	Other cranial nerve deficits
	Scoliosis
	Pain while defecating

IV. COMS (Caudal Occipital Malformation Syndrome)

Diagnosis

New considerations about Chiari-like malformation, syringomyelia and their management





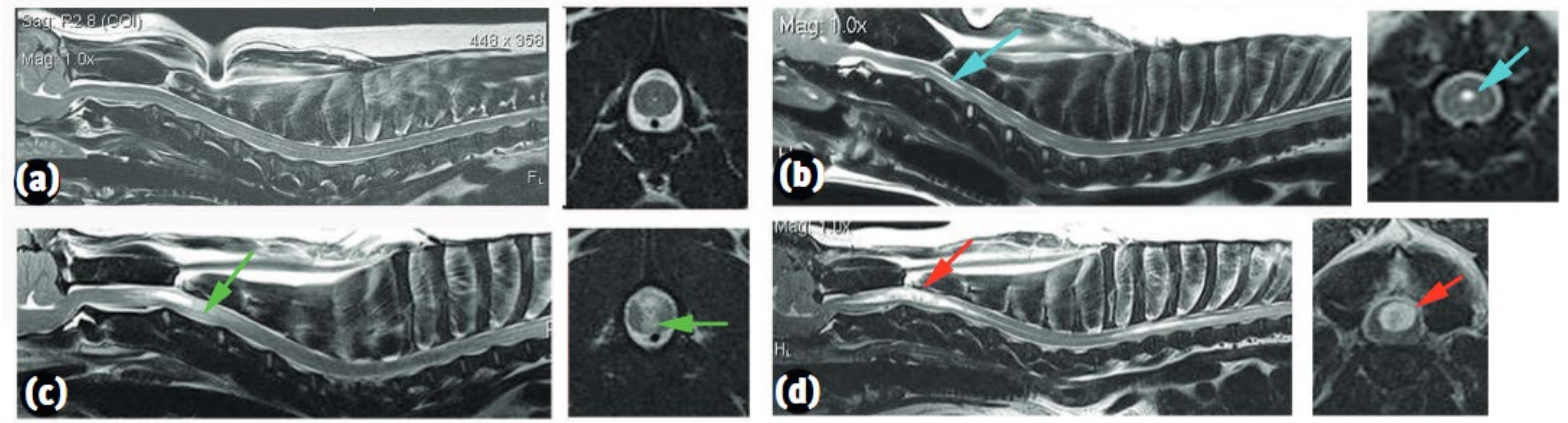


Fig 3: T2W midsagittal cervical MRI (left) and T2W transverse MRI at level of C2/C3 (right), showing the spectrum of changes from normal to syringomyelia (SM). (a) Normal MRI appearance in a dog. (b) Central canal dilatation (blue arrow). (c) Area of presyrinx (green arrow) in the spinal cord (dorsal) and ventral columns surrounding a small syrinx. (d) The same dog as in (c) but six years later and now with a fully developed SM (red arrows) which is asymmetrical and expanding the spinal cord

Medical management

TABLE 2 Commonly Used Drugs for the Management of Chiari-like Malformation and Syringomyelia in Dogs

DRUG	INDICATION	DOSE	SIDE EFFECTS	COMMENTS
Gabapentin	Neuropathic pain	▪ 10–30 mg/kg PO q8–12h	Sedation, ataxia	Can be used long term or indefinitely.
Pregabalin	Neuropathic pain	▪ 2 mg/kg PO q8–12h (starting dose)	Sedation	Consider compounding.
Omeprazole	Syringomyelia, hydrocephalus	▪ 0.5–1 mg/kg PO q24h	None	May reduce the production of CSF.
Prednisone	Neuropathic pain, inflammation, severe syringomyelia	▪ 0.5 mg/kg PO q12–48h	Polyuria, polydipsia, polyphagia, panting, diarrhea	Pulse therapy preferred or low-dose chronic therapy. Caution with chronic use. Periodic serum chemistry is recommended.
Amantadine	Neuropathic pain	▪ 3–5 mg/kg PO q12–24h	Agitation, diarrhea	Not recommended as monotherapy.
NSAIDs	Pain, inflammation	▪ Carprofen 2.2 mg/kg PO q12h or 4.4 mg/kg q24h ▪ Meloxicam 0.1 mg/kg PO q24h ▪ Grapiprant 2 mg/kg PO q24h	Vomiting, diarrhea	Periodic serum chemistry is recommended. Caution with chronic use. Grapiprant may be relatively expensive.
Opioids	Neuropathic pain	▪ Tramadol 4–5 mg/kg PO q6–12h ▪ Acetaminophen (10–15 mg/kg) + codeine (1–2 mg) PO q8–12h	Sedation, ataxia	Controversy over effectiveness of tramadol. Caution with chronic acetaminophen use. Acetaminophen is fatal in cats.

TABLE 3 Medication Recommendations Based on Severity of Clinical Signs

LEVEL OF SEVERITY	CLINICAL SIGNS	RECOMMENDED DRUG THERAPY
Mild	Occasional scratching + rare yelp	Gabapentin + omeprazole
Moderate	Persistent scratching + daily vocalizations	Gabapentin + NSAID or opioid + omeprazole
Severe–acute	Constant, severe pain	Prednisone (pulse therapy) + gabapentin + opioid + omeprazole
Severe–chronic	Scratching that interrupts daily activities, multiple daily vocalizations	NSAID + opioid + amantadine + gabapentin + omeprazole

Surgical Indication

1) Patients that have severe clinical signs, have CM and syringomyelia (diameter >3 mm)

2) Patients that fail medical management, or when SM progresses despite medical management.

→ In one study, 75% of patients with CMSM that were medically managed over 39 months had progression of clinical signs.

- The two primary goals of surgery for CMSM

(1) improve patient comfort and (2) slow or stop the progression of syringomyelia.

- Unfortunately, existing preoperative syringomyelia does not regress postoperatively; thus, it is unlikely that the preoperative level of NP (mainly in the form of phantom scratching) will completely resolve postoperatively without adjunctive medication.

IV. COMS (Caudal Occipital Malformation Syndrome)

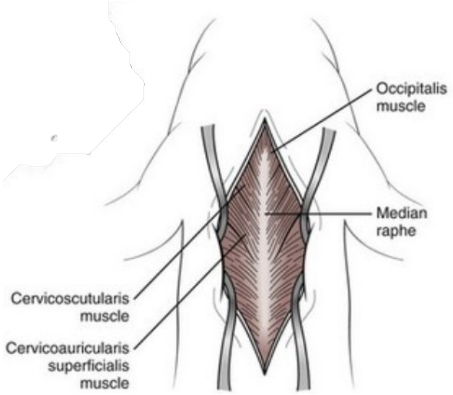
Anatomical feature	Study finding(s)	Possible implication
Syrinx presence	If a syrinx is detected in a assymptomatic dog having MRI screening prior to breeding then there is a higher change that this dog may develop clincial signs of CMSM later in life compared to a dog without a visible syrinx (83) However dogs with no clinical signs at the age of 6 are more likely to remain asymptomatic (45)	Early development of syringomyelia is more likely to be associated with clinical signs even if the dogs is initialy assymptomatic
Site of syrinx	In CKCS, SM tends to develop first within the C2–C4, T2-T4, and T12-L2 spinal-cord segments (77, 84, 85).	SM development may be associated with subarachnoid space narrowing and/or change in the angulation of the vertebral canal
	Axial stress increases in the cranial cervical and cervico-thoracic regions where the spinal cord has most curvature (86)	Increased axial stress at the site of spinal curvature may explain the syrinx distribution in the CKCS
	In CKCS 76% of dogs with a syrinx at C1-C4 also had a syrinx in the C5-T1 and T2-L2 regions and 49% had a syrinx in the L3-L7 region (85)	In CKCS MRI imaging of the cranial cervical region only has high sensitivity for detection of SM however the extent of the disease may be underestimated
Syrinx size and symmetry	Pain is positively correlated with SM transverse width and symmetry on the vertical axis (32, 87)	Dogs with a wider asymmetrical SM more likely to experience pain
	Phantom (fictive) scratching is associated with a mid-cervical spinal cord segment syringe with extension to the superficial dorsal horn (88)	Phantom (fictive) scratching is associated with damage to the mid-cervical superficial dorsal horn
	Dogs with a wide syrinx and dorsal gray column damage are also more likely to have cervicothoracic scoliosis (87)	Gray column damage can result in an imbalance of proprioceptive information and cervical dystonia (89)

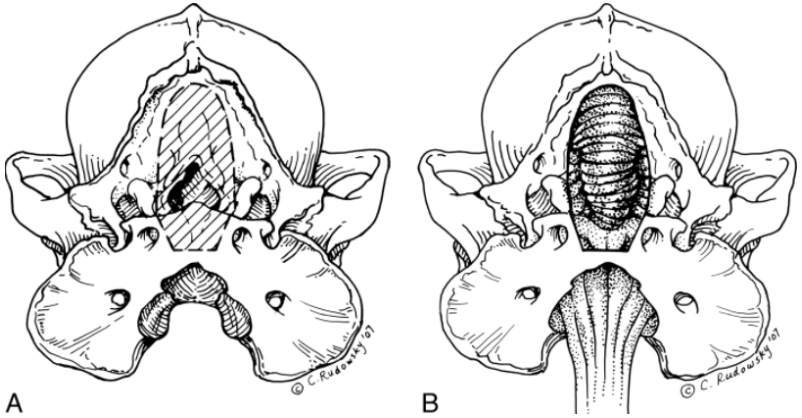
IV. COMS (Caudal Occipital Malformation Syndrome)

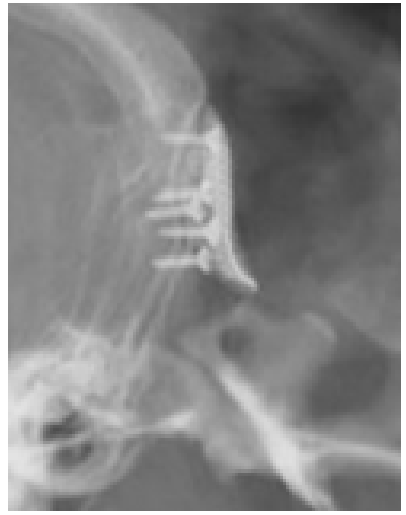
Anatomical feature	Study finding(s)	Possible implication
Parenchymal (brain) volume	The absolute and relative volume of the CKCS skull is similar to other brachycephalic toy dog breeds but CKCS have a greater volume of parenchyma within the caudal cranial fossa (69) and CKCS with early onset SM have a larger volume of parenchyma within a smaller caudal cranial fossa compared to older CKCS with CM only (57, 61, 70)	Mismatch in skull and brain volume is associated with development of SM.
Cerebellar volume	CKCS have relatively increased cerebellar volume compared to other control breeds and this is associated with development of SM (71)	Caudal cranial fossa overcrowding is associated with development of SM
Cerebellar herniation	Typically present but size does not predict SM (62, 72, 73)	Obstruction of CSF channels though the foramen magnum contributes to the pathogenesis of SM but there must also be other predisposing factors.
	Positive association with the size of foramen magnum and size of cerebellar herniation (62)	Overcrowding of the caudal cranial fossa causes supraoccipital bone resorption (occipital dysplasia) and widening of the foramen magnum over time.
	The length of the cerebellar herniation increases with time. The size of the foramen magnum also increases (74, 75)	
Cerebellar pulsation	CKCS with CM and SM have significantly greater pulsation of the cerebellum compared to CKCS with CM only and other control breeds (76)	Abnormal cerebellar pulsation could lead to a mismatch in the timing of the arterial and CSF pulse waves predisposing SM (77, 78)
Position of cerebellum relative to occipital lobe	Rostrotentorial craniocerebral disproportion results in the occipital lobes being displaced caudally so that cerebellum is invaginated under the occipital lobes (40).	Overcrowding in both cranial and caudal fossa affects position of cerebellum
Medullary elevation (medullary kinking)	Higher medullary kinking index is associated with clinical signs in CKCS and Chihuahuas (47, 79)	Dogs with higher medullary elevation / kinking are more likely to have clinical signs
Caudal medulla (obex) position	Association between more caudal brainstem positions and presence of SM (79)	Caudal displacement of the obex may increase risk of SM
CSF flow	Higher peak CSF flow velocity at the foramen magnum with a lower CSF flow velocity at C2–C3 predicts SM (80)	SM is associated with alterations in the CSF velocity profile
	Turbulence at the foramen magnum and at the C2–C3 disc significantly associated with SM (80)	
	Presence CSF signal-void sign in mesencephalic aqueduct on T2W is associated with SM and increased ventricular size (81)	
Ventricle dimensions	In CKCS ventricle dimensions are positively correlated with syrinx width (57)	Evidence that SM is related to CSF channel obstruction
	Are not correlated with seizures (nor is caudal cranial fossa overcrowding) (82)	Epilepsy and CM in CKCS should be considered unrelated

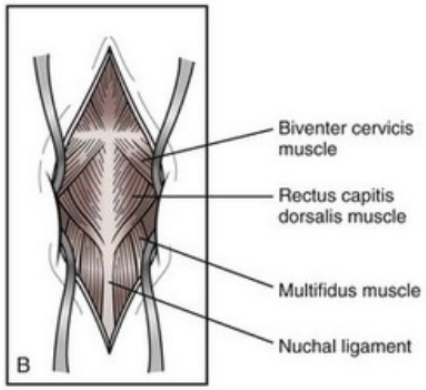
Surgical treatment : Foramen magnum decompression (FMD)

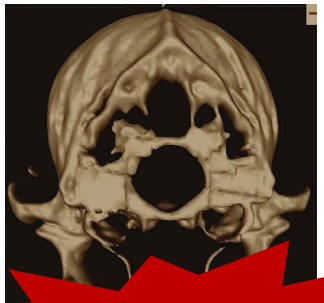
Suboccipital craniectomy + Dorsal laminectomy of the atlas (± axis) + Durotomy



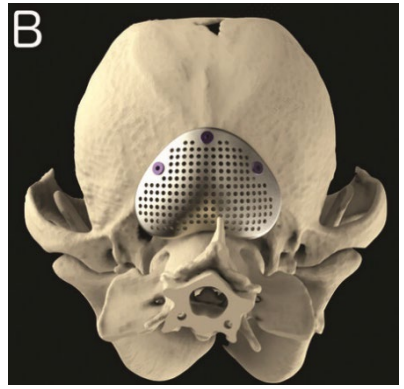








Caution!



Prognosis

- The surgical success rate of FMD in dogs with COMS: about 80%
- The relapse rate: approximately 25% to 47%
  - ✓ According to a study on FMD with titanium/PMMA cranioplasty, the short-term success rate is 81% and the recurrence rate is 0%-8%.
  - ✓ Additionally, a recent analysis of more than 100 cases involving this surgical technique determined the re-operative rate to be 7%.
- 80% to 94% of patients exhibit early postoperative improvement following FMD
- Some patients show relapse of clinical signs approximately 1 year or more after surgery.
- Most patients experience little postoperative morbidity, and early surgical intervention has been recommended.

Summary

- Skull Tumors: Low-grade tumors can have a favorable prognosis if completely excised. However, the recurrence rate is relatively high.

- Brain Tumors: The decision for surgical intervention should be carefully considered. For patients with severe clinical signs, factors such as tumor location, size, and invasiveness should be evaluated.
- Feline meningiomas generally have a good prognosis.
- In cases of glioma or pituitary tumors, adjuvant chemotherapy and radiation therapy should be considered depending on the tumor's location and size.
- Adverse effects are more likely to occur within a month.

- Hydrocephalus: A VP shunt may be indicated when there is no response to medical treatment and when symptoms arise due to increased intracranial pressure. Complication rates are high within the first 6 months post-OP.

- COMS (Caudal Occipital Malformation Syndrome): Foramen magnum decompression (FMD) may be indicated in patients with persistent pain or neurological symptoms that are not managed by medication.
- Although recurrence can occur after one year post-FMD, morbidity remains relatively low.

Thank You for
Your Attention

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