Surgical techniques for cervical spine fixation

Frank Steffen
PD Dr.med.vet. Dipl ECVN
Section neurology/neurosurgery

University of Bern | University of Zurich

vetsuisse-faculty
When is surgical stabilization needed?

Border Collie: Tetraparesis after rolling over. Previous CT of cervical area without abnormalities.
When is surgical stabilization needed?

- Fracture induced instability with stenosis
- Malformations (?)
- Degenerative conditions/IVDD (?)
- Failed decompressive procedure (ventral slot)
- Discospondylitis (?)
Diskospondylitis C3-4
GSD, 1y, cervical pain
Same dog, after 10 days of antibiotics: non-ambulatory tetraparesis
Failed ventral slot decompression
Methods of cervical stabilization

- Indirect Decompression using stabilization/distraction/fusion procedures
  - Screw/Pins, PMMA
  - Locking plates
  - transarticular screws
  - Screw/washer – Technique
  - Intervertebral Distractor devices (bonegraft, cages made of titan- or carbonfiber) with additional plating
  - intervertebral Distractors (PMMA-Plug, Stand-alone cage)

- disc prosthesis /Total disc replacement (TDR)
Short-term success rates were high (approximately **80 per cent**), but there was a high rate of recurrence (around 20 per cent) after any surgical treatment, suggesting the possibility that the syndrome should be considered a multifocal disease of the caudal cervical region. Statistical analysis revealed no significant differences in success rates between the various reported decompressive surgical techniques.
„Level of evidence“

Quality hierarchy pyramid

Where we are

Where to go
Bruecker et al. 1989

Intravertebral screws/pins-PMMA bridge
Results

• Bruecker 1989: 93% successful, (37/40, 3-50 months follow-up)

![X-ray image with screws]

8 dogs developed a second episode (domino-lesion)
Longterm success: 73%
Bicortical Implant Insertion in Caudal Cervical Spondylomyelopathy: A Computed Tomography Simulation in Affected Doberman Pinschers

DANIELE CORLAZZOLI, DVM

High risk for violation of vertebral canal, vertebral artery and intervertebral foramen
Monocortical screw fixation was biomechanically equivalent to bicortical fixation
McKee 1999

Screw/washer

initially successful in 78 dogs
Longterm outcome: 17/65 Domino-Lesions
Interbody PMMA plug for distraction-stabilization of CCSM

Dixon et al., JAVMA, 1996

22 dogs: 21 improved, 11 completely normal,

Immediate postop high stability/Stability lost at 8 weeks/increased at 24 weeks. No bony Fusion, distraction not maintained.
Use of the ComPact UniLock System for ventral stabilization procedures of the cervical spine

A retrospective study

K. Voss¹, F. Steffen², P. M. Montavon³
¹Clinic for Small Animal Surgery, and ²Neurology, University of Zurich, Switzerland

Good results for cervical fractures
Use of the ComPact UniLock System for ventral stabilization procedures of the cervical spine
A retrospective study

K. Voss¹, F. Steffen², P. M. Montavon¹
¹Clinic for Small Animal Surgery, and ²Neurology, University of Zurich, Switzerland

Chihuahua, 8 yrs
Non-ambulatory tetraparesis
Hydrated nucleus pulposus extrusion
No improvement after ventral slot sx
Non-ambulatory, persistent pain during 10 days
Surgically induced instability with subtle subluxation?
Revision sx: ambulatory status within 3 days
Cervical malformations

Yorkshire Terrier, 1 y: generalized ataxia
Caudal cervical spondylomyelopathy/DAWS

Use of the ComPact UniLock System for ventral stabilization procedures of the cervical spine
A retrospective study
K. Voss¹, F. Steffen², P. M. Montavon¹
¹Clinic for Small Animal Surgery, and ²Neurology, University of Zurich, Switzerland

Loss of distraction: all dogs

Early screw pullout: 2/6
LOCKING PLATES PLUS INTERVERTEBRAL DISTRACTION

Cervical Spinal Locking Plate in Combination with Cortical Ring Allograft for a One Level Fusion in Dogs with Cervical Spondylotic Myelopathy

ROBERT L. BERGMAN, DVM, MS Diplomate ACVIM (Neurology), JONATHAN M. LEVINE, DVM, Diplomate ACVIM (Neurology), JOAN R. COATES, DVM, MS. Diplomate ACVIM (Neurology), ANNE BAHR, DVM, MS, Diplomate ACVIM,
Bianca F. Hettlich, DVM, Diplomate ACVS, and Sharon C. Kerwin, DVM, MS, Diplomate ACVS

Cervical Spine Locking Plate Fixation for Treatment of Cervical Spondylotic Myelopathy in Large Breed Dogs

ERIC J. TROTTER, DVM, MS, Diplomate ACVS

6/21 dogs implant loosening
1/21 pseudarthrosis w secondary extradural compression
Distraction–Fusion for Caudal Cervical Spondylomyelopathy Using an Intervertebral Cage and Locking Plates in 14 Dogs

Frank Steffen¹, Dr Med Vet Diplomate ECVN, Katja Voss¹, Dr Med Vet Diplomate ECVS, and Joe P. Morgan², Prof Dr Med Vet Diplomate ACVR

¹Sections of Small Animal Surgery/Neurology, Vetsuisse Faculty of the University of Zurich, Zurich, Switzerland and ²Diagnostic Imaging and Radiation Oncology, Vetsuisse Faculty of the University of Zurich, Zurich, Switzerland

Step 1

C6
Distraction–Fusion for Caudal Cervical Spondylomyelopathy Using an Intervertebral Cage and Locking Plates in 14 Dogs

Frank Steffen¹, Dr Med Vet Diplomate ECVN, Katja Voss¹, Dr Med Vet Diplomate ECVS, and Joe P. Morgan², Prof Dr Med Vet Diplomate ACVR

¹Sections of Small Animal Surgery/Neurology, Vetsuisse Faculty of the University of Zurich, Zurich, Switzerland and ²Diagnostic Imaging and Radiation Oncology, Vetsuisse Faculty of the University of Zurich, Zurich, Switzerland

- Implant position
1st goal: Decompression

pre

C7

post
2nd goal: bony fusion

Postoperative
No mineralisation within cage

6 months
Signs of mineralisation of bony graft

12 months
progressive fusion within cage
Results (1 year follow-up)

- **Clinical outcome:** 9 dogs improved status, all dogs without signs of pain
- **2 dogs:** adjacent segment disease *(Domino-lesion)*
- Clinical improvement: 80%

- **Technical outcome:** 100% Implant stability
- Fusion rate: 100%
How important is bony fusion?

„Without bony fusion, implant failure is a time dependent certainty“ (Human situation)

Assessment of bony fusion?

Fusion cannot be fully assessed with imaging either RX nor CT
Only 14% of congruency between CT and histologic evaluation in an animal model  
(Cook et al., Spine, 2004)

Criteria for successful fusion:
1. No evidence for implant loosening
2. Absence of peri-implant lucency
3. Bony bridging inside, dorsal and/or ventral to implant  
   McAfee et al, Spine, 2001
Why (seemingly) better outcome with an intervertebral implant than with plating alone?

Effect of an Intervertebral Disk Spacer on Stiffness After Monocortical Screw/Polymethylmethacrylate Fixation in Simulated and Cadaveric Canine Cervical Vertebral Columns

Bianca F. Hettlich¹, Dr Med Vet, Diplomate ACVS, Matthew J. Allen¹, Vet MB, PhD, Gabriela S. Glucksman¹, BS, Geoffrey T. Fosgate², DVM, PhD, Diplomate ACVPM, and Alan S. Litsky³,⁴, MD, ScD

Intervertebral spacers increase construct stiffness significantly
Problems associated with cage/plate stabilisation

**Subsidence**

- Loss of distraction due to impression of the cage into endplates: 9/14 dogs within first 6 weeks postop

Human cage surgery: 30% subsidence
C6-7 highest risk
No influence on outcome or fusion
*Bartels et al. Neurosurgery, 2006*
Macroscopic appearance of subsided cage

Vertebral canal

Enplate after removal of subsided cage
Note „foot print“ of the implant,
Major complication:

adjacent segment disease (ASD)/Domino lesion

Incidence: 20-30% in all stabilizing procedures, weeks – years after the procedure
ASD

- Development of new radiculopathy or myelopathy referable to a motion segment adjacent to the site of a previous arthrodesis of the cervical spine
- ASD cannot be distinguished from natural progression of a degenerated spinal unit
- New lesions occur also after medical or non-stabilizing procedures (Da Costa, JAVMA, 2007)

Adjacent segment degeneration
6 months postop present in 11/11 dogs (Steffen et al. 2011)
Prevention of ASD

• Careful soft tissue preparation (i.e. elevation of longus colli instead of transection) because of supportive role of musculolig. Structures
• Avoid injury to adjacent disc during distraction
• plate should be 5mm away from the endplate
• Screws angled away from endplate (Kepler et al. Orthop Clin N Am 2012)
• Avoid overdistraction of affected level (personal observation)
ASD 4 weeks after distraction – fusion procedure

Traction responsive lesion
Management of ASD

• No guidelines in veterinary medicine
• Humans: ASD plate arthrodesis and stand-alone cage fusion reported to be effective (Kepler et al. Orthop Clin N Am 2012)
• Canine: medical treatment provided only short-term control of ASD (Steffen et al., 2011)
• Surgical management (probably) mandatory for cervical ASD in dogs
Surgical management of ASD: BMD 7 y

Immediate postop traction responsive
Annulus protrusion C6-7

Severe neck pain 12 weeks postop
Adjacent level sx: Removal of original plates and, distraction using a 2nd carbonfiber fusion cage C5-6, ventral plating over 3 vertebrae
**Dobermann, 10 y fs:** 4 years after successful C6-7 stabilization.
Acute onset of cervical pain and paraparesis

Disc degeneration and protrusion with compression of C5-6. Bony bridging ventral to the plates (white arrow)
Adjacent level sx: Because of a solid bony bridge C6-7 screws were removed only unilaterally. A new locking plate was placed on-top the original and fixed with screws with a larger diameter through original corridors.
Further evolutions I

L-Cox

Distractable cage

Comparison of the Biomechanical Properties of a Ventral Cervical Intervertebral Anchored Fusion Device With Locking Plate Fixation Applied to Cadaveric Canine Cervical Spines

Bernhard Schölthorn1, DVM, Alexander Bühr2, MSc, Christina Stähli2, Diplomate ECVDI, Judith Howard3, Diplomate ACVIM, and Franck Forterre3, Diplomate EVCS

1 Department of Small Animal Surgery, Veterinary Faculty of Bern, Bern, Switzerland; 2 Institute for Surgical Technologies and Biomechanics (ITB), University of Bern, Bern, Switzerland; 3 Department of Radiology, Veterinary Faculty of Bern, Bern, Switzerland and 4 Diagnostic Clinical Laboratory, Veterinary Faculty of Bern, Bern, Switzerland

Caudal cervical arthrodesis using a distractable fusion cage in a dog

C. Adreva da Silva², F. Bernard³, J.-F. Bardet³

2 Small Animal Referral Clinic, Neudorf et van, France; 3 University Veterinary Hospital, School of Agriculture, Food Science & Veterinary Medicine, University College Dublin, Dublin, Ireland

Similar biomechanical stability as a locking plate
Further evolutions II

Combined Dorsal and Ventral Stabilization in Traction-Responsive Cervical Spondylomyelopathy

D. Corlazzoli; L. Porcarelli; F. Raimondi
Clinica Veterinaria Roma Sud, Roma, Italy

ACVIM Proceedings 2013
The new kid: disc arthroplasty

Original idea: preserving cervical spinal segment motion thereby reducing the risk for ASD.

In Vitro Biomechanical Comparison of Cervical Disk Arthroplasty, Ventral Slot Procedure, and Smooth Pins with Polymethylmethacrylate Fixation at Treated and Adjacent Canine Cervical Motion Units

P. FILIPPO ADAMO, DVM, Diplomate ACVIM, HIROHITO KOBAYASHI, DVM, MARK MARCEL, DVM, PhD, Diplomate ACVIM, and RAY VANDERBY Jr., PhD

A

C
Cervical arthroplasty in two dogs with disk-associated cervical spondylomyelopathy

Adequate spinal cord decompression was achieved. Intervertebral mobility was not achieved or lost in both cases due to collapse of the IVD space/subsidence of the implant.

Cervical disc arthroplasty using the Adamo spinal disc in 30 dogs affected by DAWS at single and multiple levels. Proceeding, ECVN/ESVN 26th Symp Paris 2013
Human cervical surgery

Optimistic notion that TDR would lower the rate of complications has not materialised

Statistically, there is the same risk für ASD after disk-arthroplasty (16%) and stabilization procedures (18%)
Disc replacement using Pro-Disc C versus fusion: a prospective randomised and controlled radiographic and clinical study
Nabhan et al., Eur Spine J 2007

significant pain reduction postoperatively, without significant difference between both groups (P > 0.05). Cervical spine disc prosthesis preserves cervical spine segmental motion within the first 6 months after surgery. The clinical results are the same when compared to the early results following ACDF
Why is TDR not more effective than ACDF?  
Possible explanation

- Preserving motion is less important than uniform load-transmission
- Load-transmission over endplate is critical and requires complete osseous integration between implant and endplate over a large footprint.
- Bone-implant interface = mixture of fibrous tissue and bone => Continued pain despite rigid fixation
- Irregular load transmission occurs in degenerated discs and intervertebral devices with „small foot prints“ (cage, artificial discs (insufficient load transfer due to deficient interface between implant and endplate)
- Common goal of ACDF and artificial discs: produce optimal load transfer over a large foot-print with 100% bony integration
Summary

• Is a stabilizing procedure superior to a non-stabilizing decompression?
• Many procedures for management of DAWS/CCSM have been described and will be described in near future
• Level of evidence of each?
• No „state-of-the-art“ procedure can be recommended at present (see Jeffery/McKee, 2001)
• Randomized, prospective studies comparing the procedures using standardized outcome measures
Cervical spondylopathy in the dog—a review of thirty-five cases

H. R. Denny, Christine Gibbs and C. J. Gaskell
Department of Veterinary Surgery, University of Bristol, Langford House, Langford, Nr. Bristol
Your turn