



## 2025 Intracranial Hypotension Conference

Amsterdam June 28-29

# Anatomy of spontaneous spinal CSF leaks

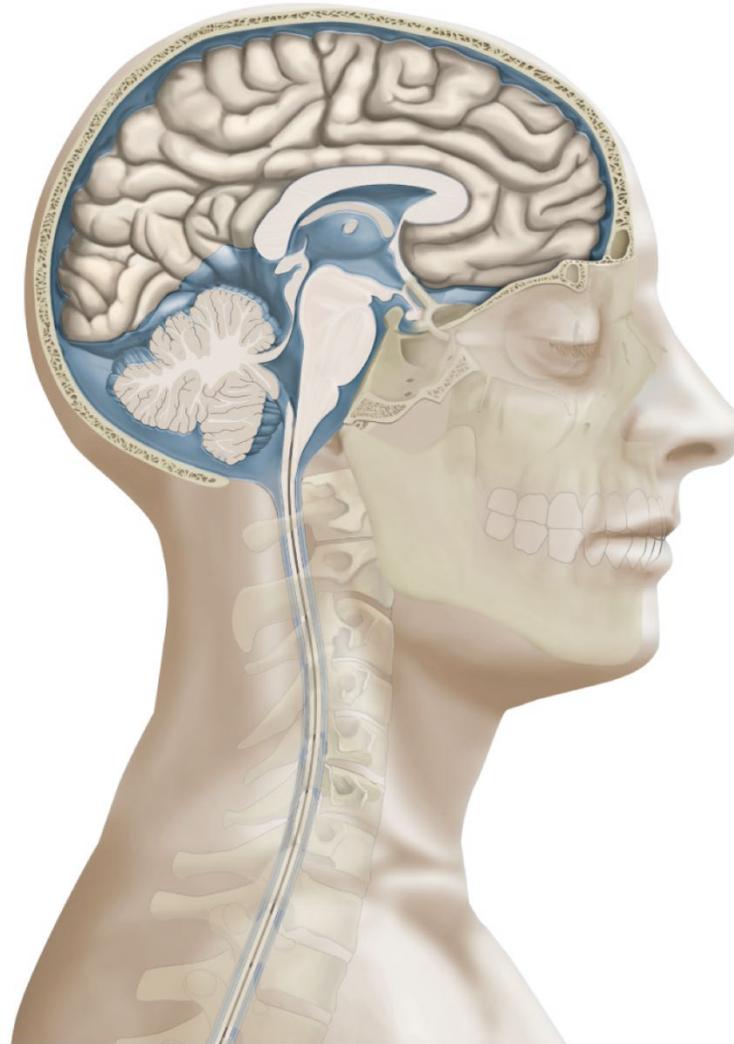
**Jürgen Beck**

Director Dept. of Neurosurgery

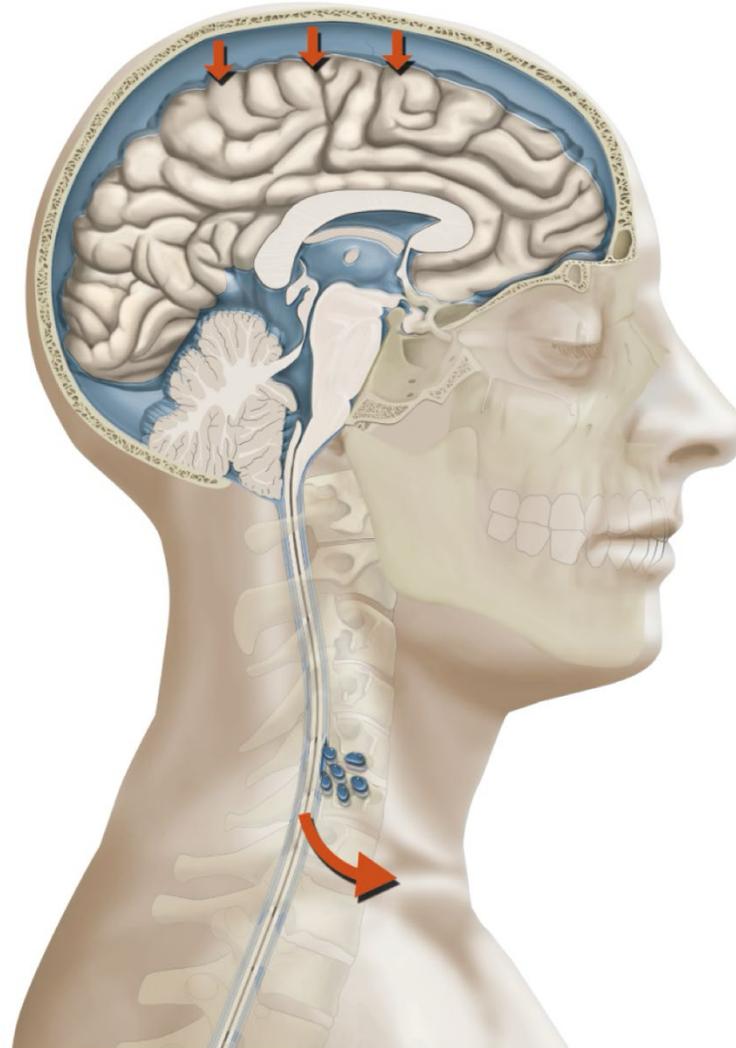
Medical Center – University of Freiburg, Germany

Chair CSF-Section - European Association of Neurosurgical Societies

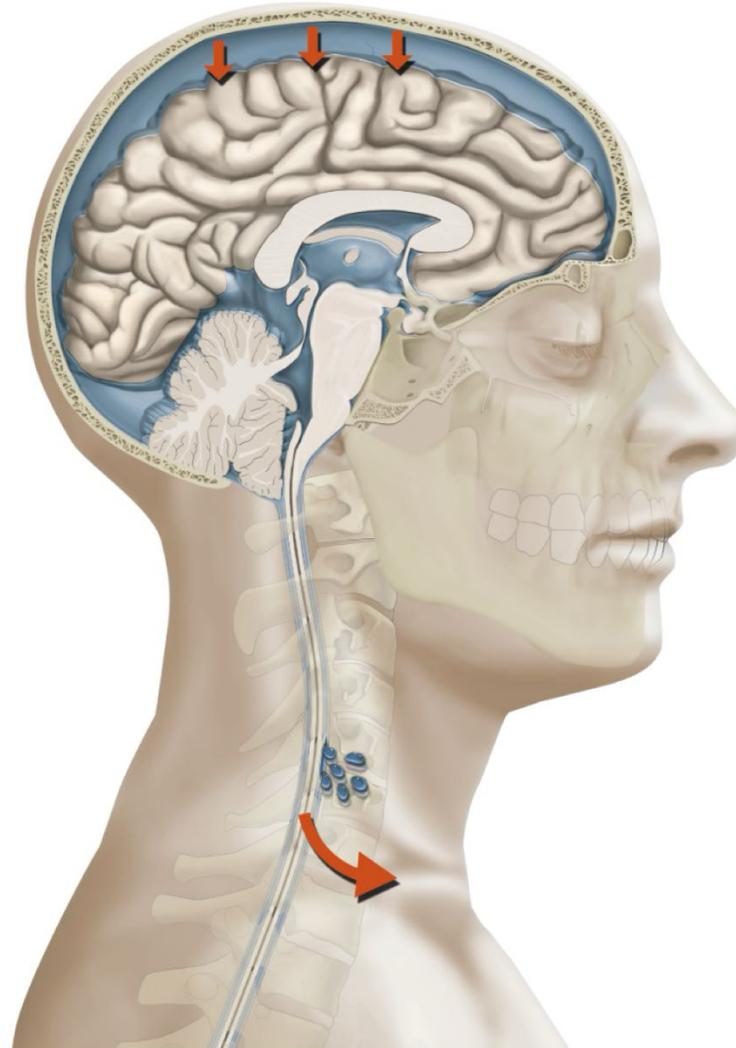
# Spontaneous Intracranial Hypotension



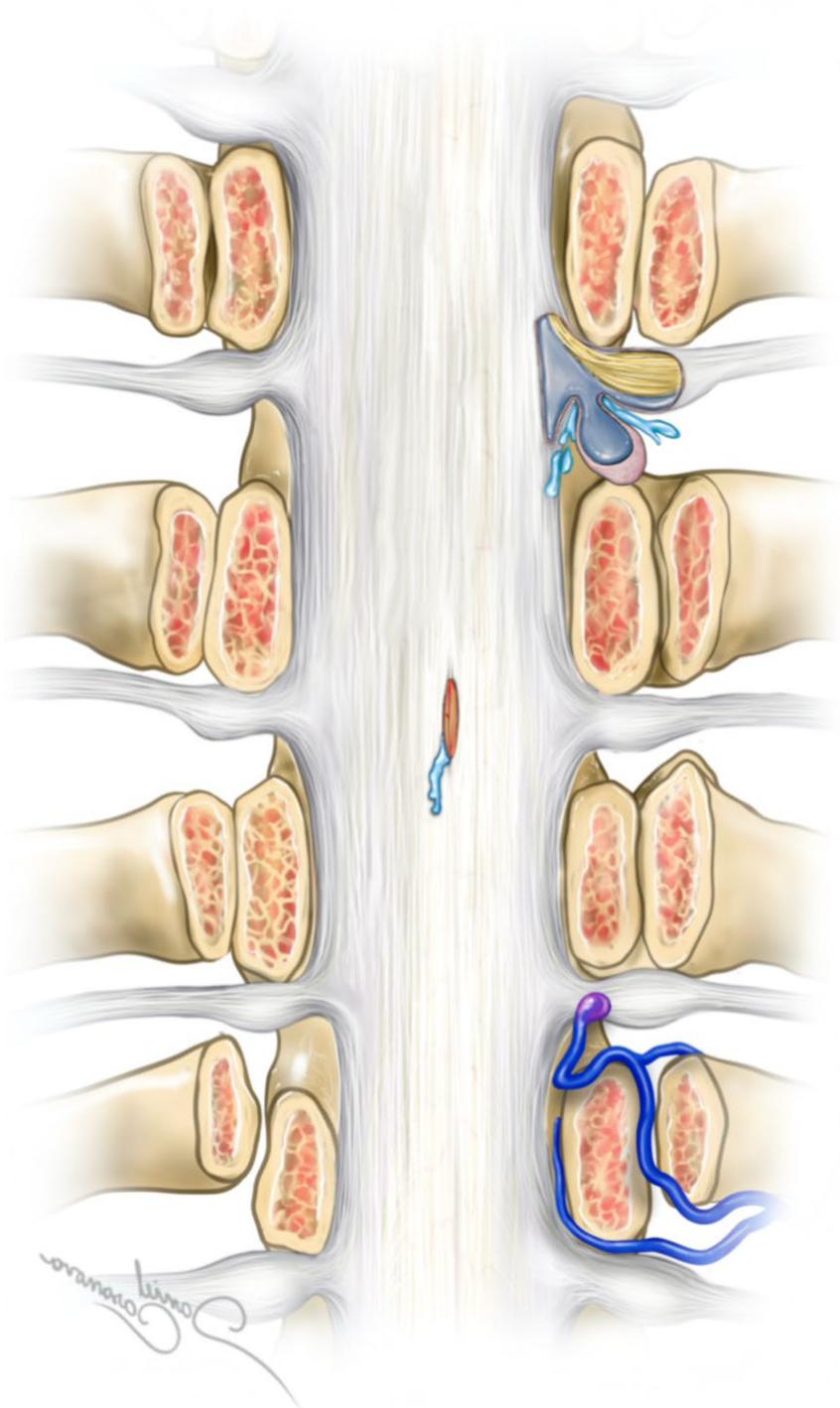
# Spontaneous Intracranial Hypotension



# Spontaneous Intracranial Hypotension



**spinal CSF leak**



← Type 2

← Type 1

← Type 3

*Overstijns et al. under review*



EANS CEREBROSPINAL FLUID  
SECTION

## International Collaborations

Inselspital Bern, Switzerland

Lindenhofspital Bern, Switzerland

UZH Zuerich, Switzerland

AKH, Vienna, Austria

University College London, UK

King's College, UK

Danish Headache Center, Denmark

Cedars Sinai, CA, USA

Stanford, CA, USA

Nagoya University, Japan

# CSF-Center Freiburg



### Neurosurgery & Neurology

J. Beck, K. Wolf, F. Volz, A. El Rahal, V. Vieira da Silva  
L. Krismer, M. Overstijns, M. Shah

### Neuroradiology

H. Urbach, N. Lützen,  
C. Zander, T. Demerath



**Nuclear Medicine**  
P.T. Meyer & Team

**Anesthesiology**  
H. Bürkle & Team

**Neuroophthalmology**  
W. Lagrèze & Team

**Neuromedical AI Lab**  
T. Ball & Team

**Medical Physics**  
M. Reisert & Team

Freiburg CSF Center  
Prof. Dr. Jürgen Beck



CSF CENTER

FREIBURG



MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST  
Baden-Württemberg



@JrgenBeck  
@Niklas\_Luetzen  
@KathaDCwolf  
@ZanderCharlotte

## Spinal CSF leaks

> 500

Consultations  
/ year

> 500

Surgeries

> 200

Boodpatches  
/ year



Research

# Spinal CSF leaks



**Type 1  
(ventral)  
~ 50%**

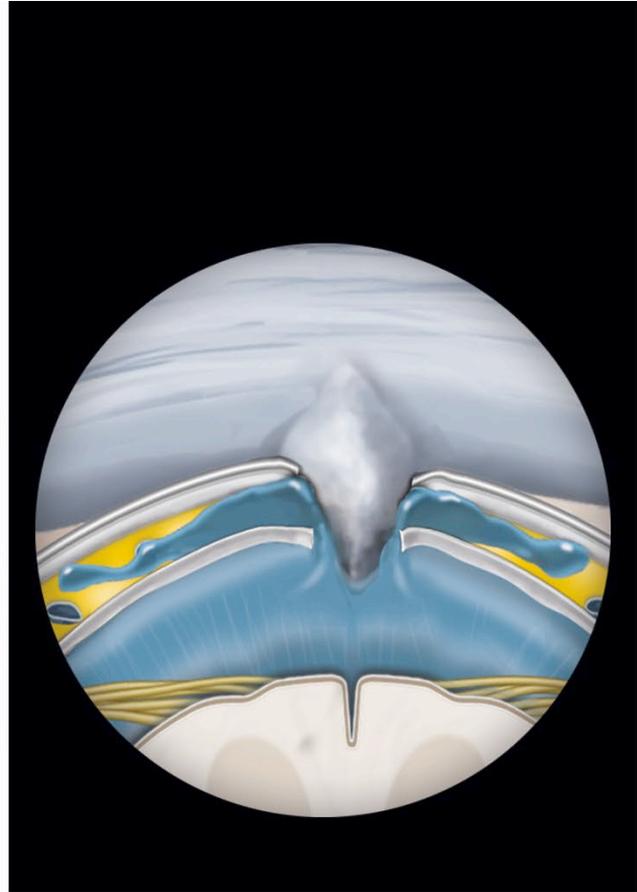
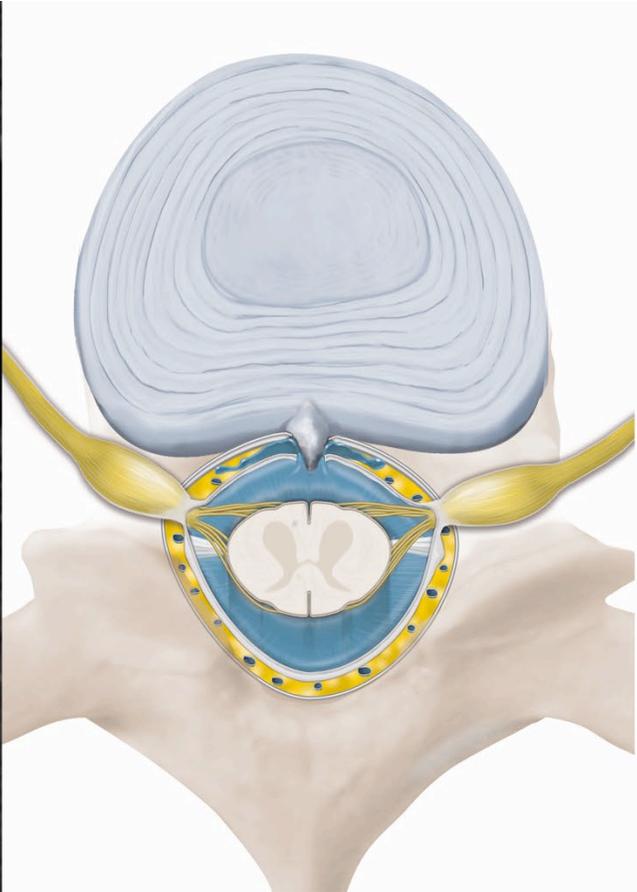


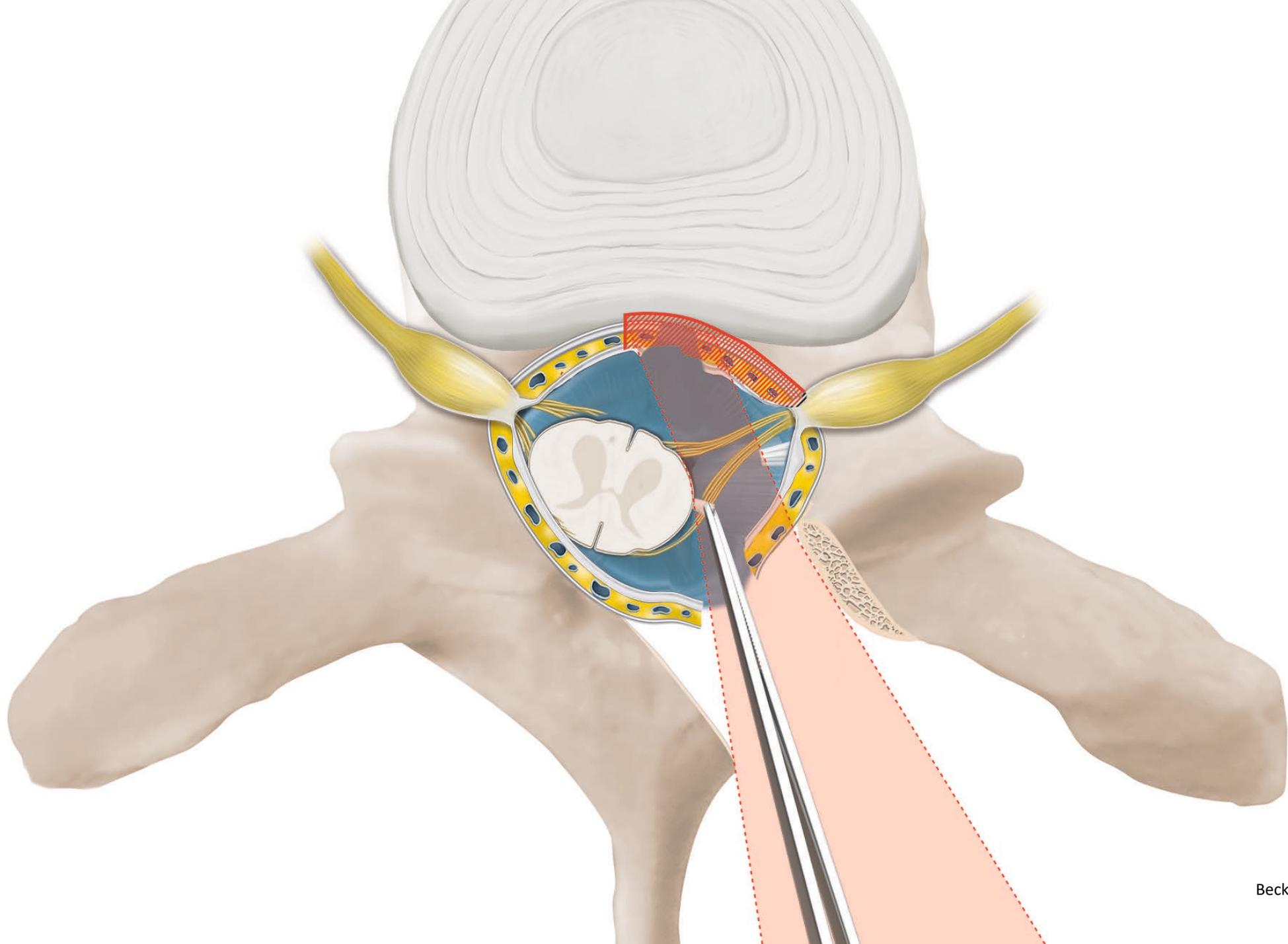
**Type 2  
(lateral)  
~ 20%**

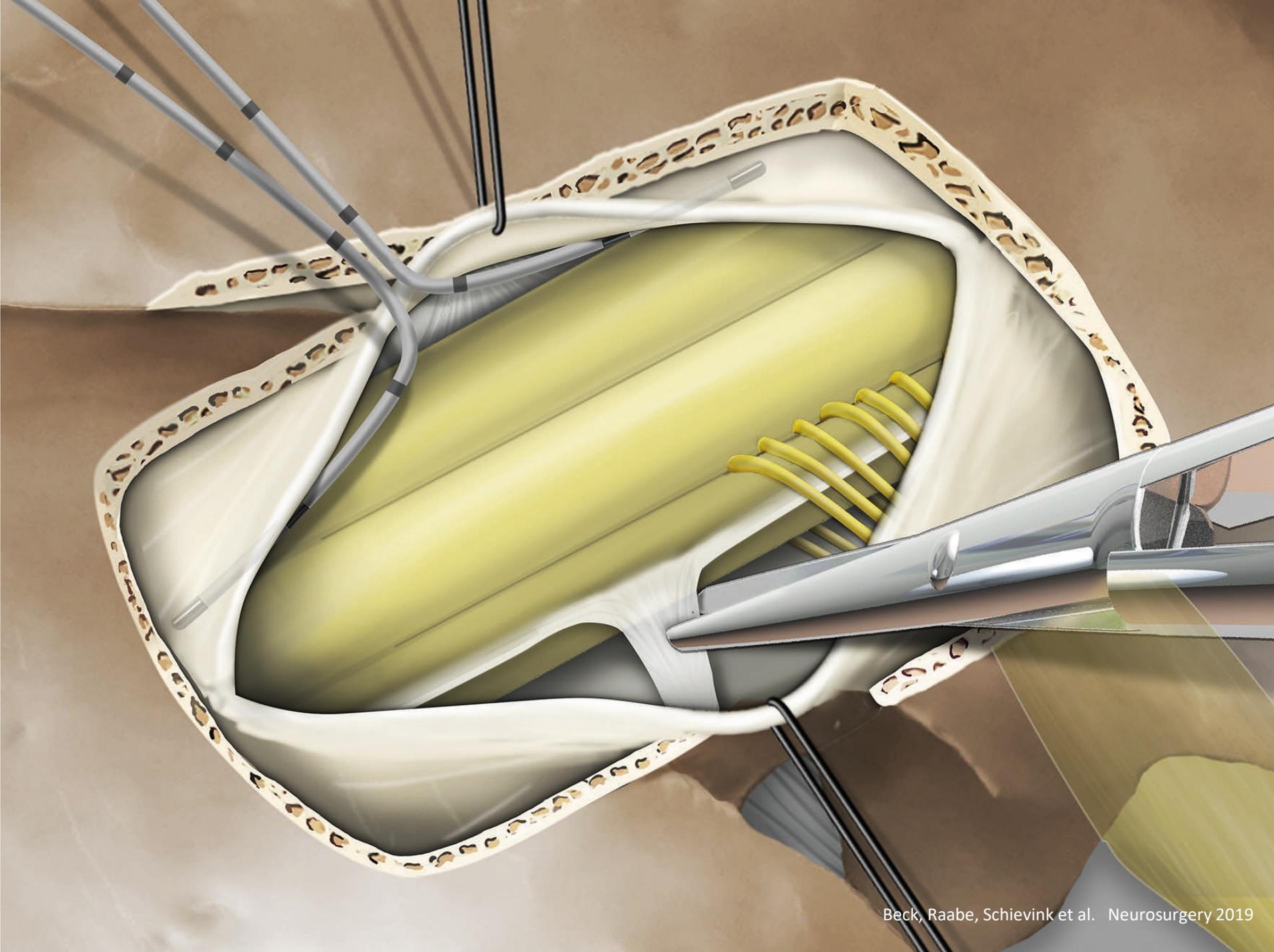


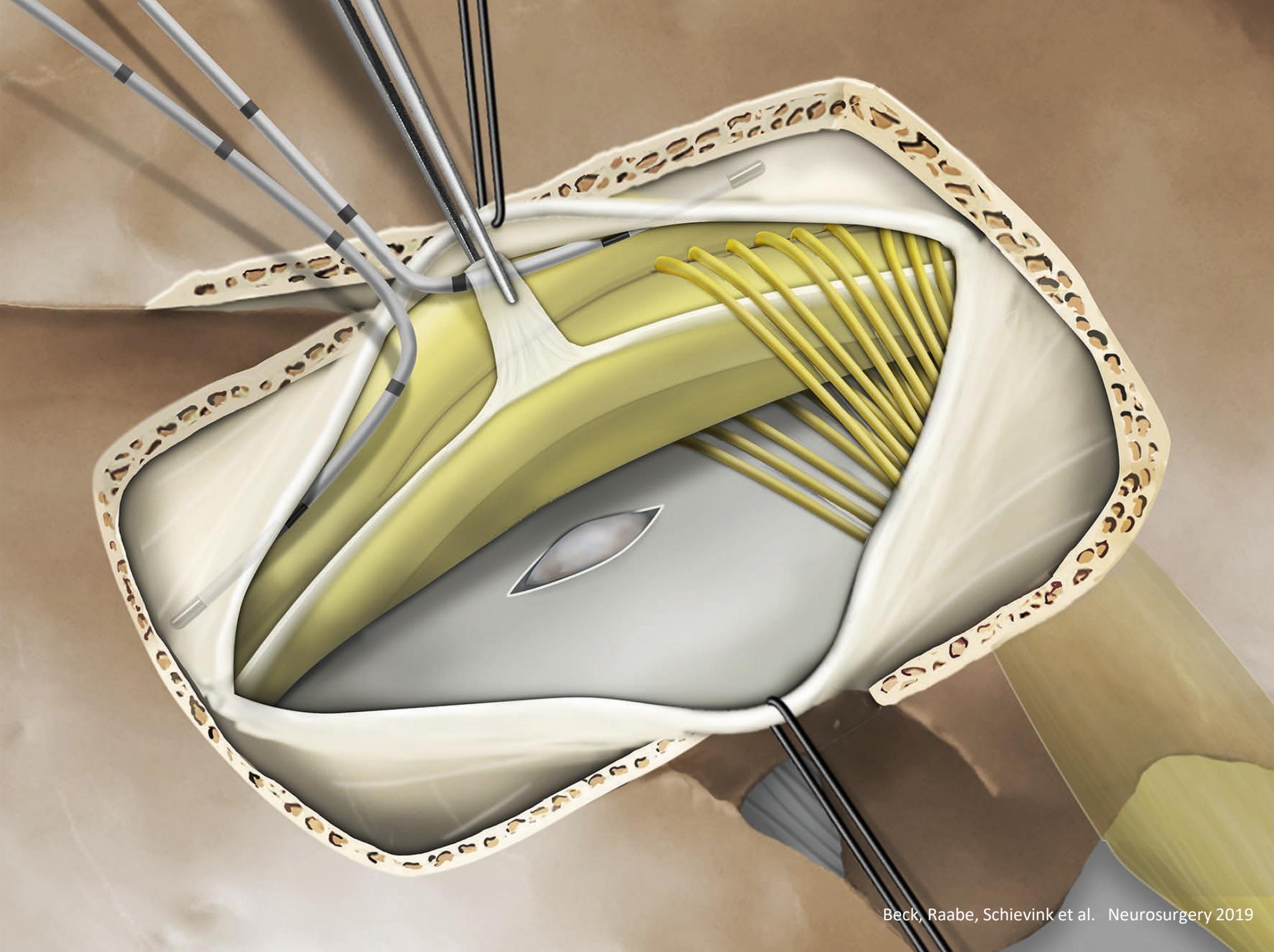
**Type 3  
(CSF-venous fistula)  
>30%**

# Ventral leak – type 1 – micro-spur

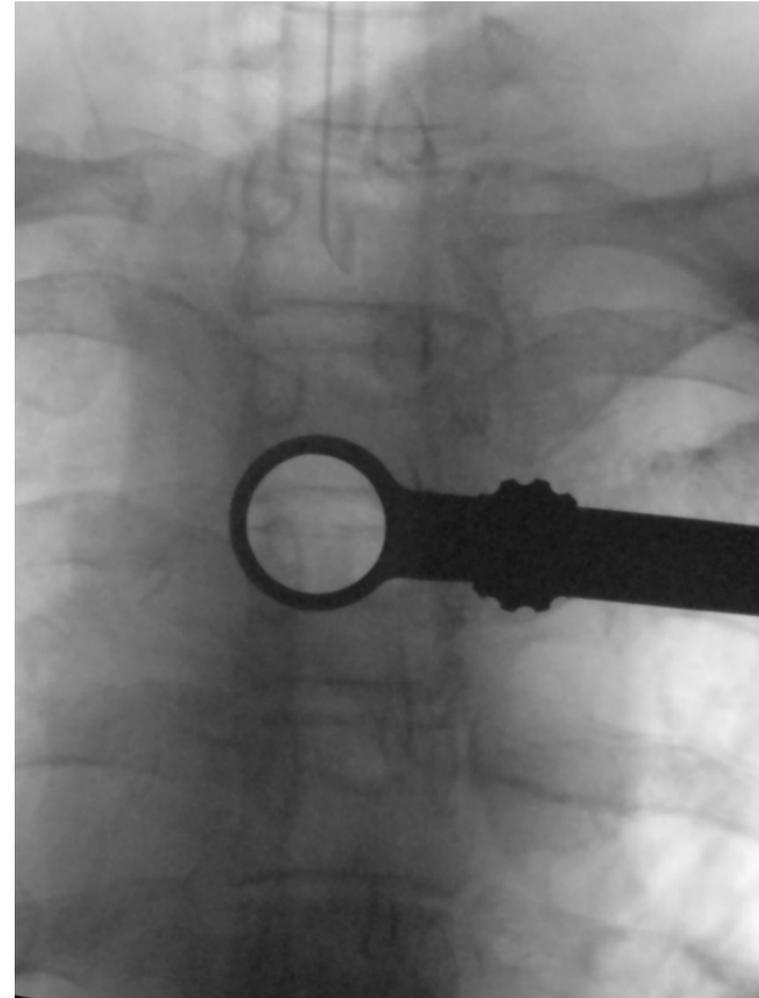
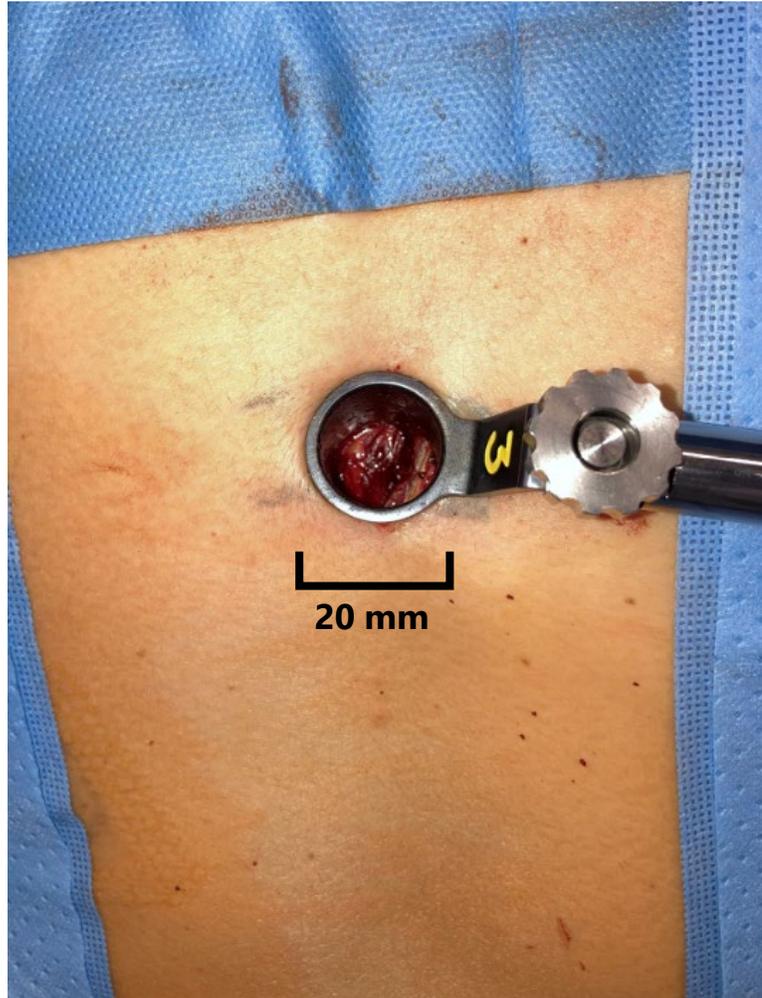




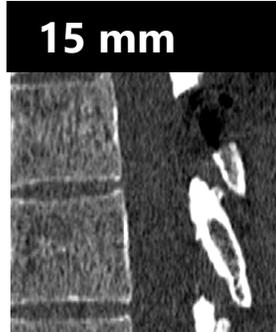




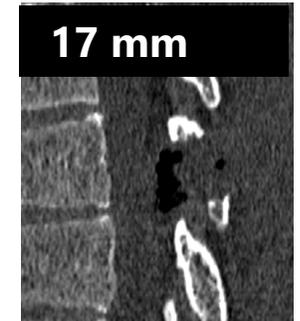
# Minimal invasive surgery – spinal CSF leaks



# Minimal invasive surgery



19,75 mm



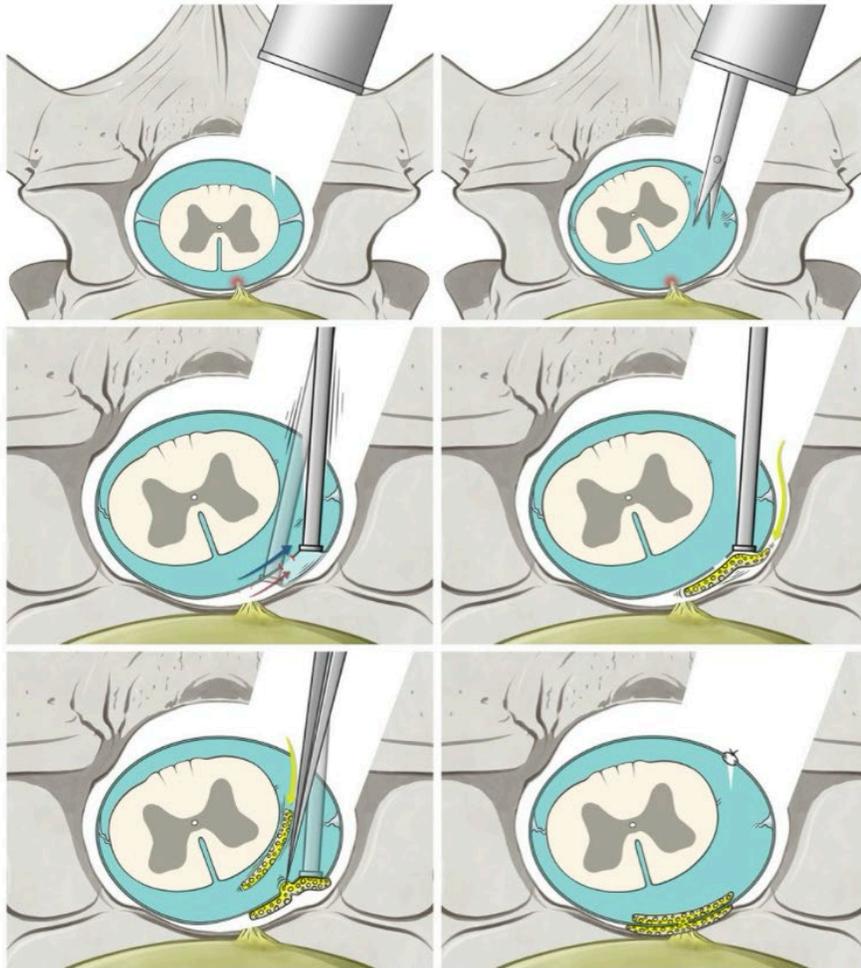
CLINICAL RESEARCH: SPINE

## Keyhole Fenestration for Cerebrospinal Fluid Leaks in the Thoracic Spine: Quantification of Bone Removal and Microsurgical Anatomy

Volz, Florian MD<sup>1</sup>; Doria-Medina, Roberto MD<sup>2</sup>; Fung, Christian MD<sup>3</sup>; Wolf, Katharina MD<sup>4</sup>; El Rahal, Amir MD<sup>1,4</sup>; Lützen, Niklas MD<sup>5</sup>; Urbach, Horst MD<sup>6</sup>; Loidl, Theresa Bettina MD<sup>7</sup>; Hubbe, Ulrich MD<sup>8</sup>; Klingler, Jan-Helge MD<sup>9</sup>; Beck, Jürgen MD<sup>7</sup>

Author Information ©

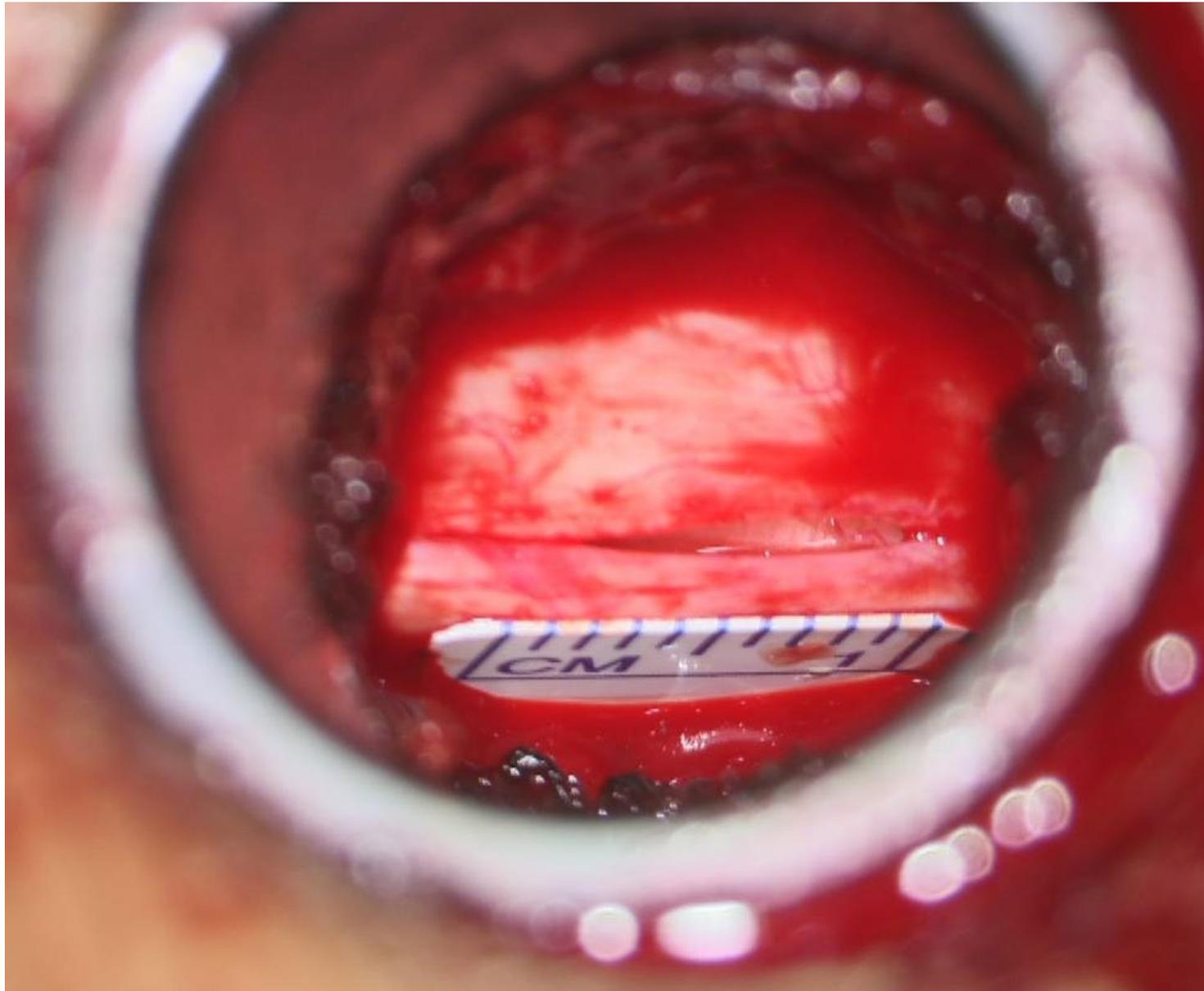
Operative Neurosurgery (10.1227/ons.0000000000001042, December 22, 2023. | DOI: 10.1227/ons.0000000000001042 ©

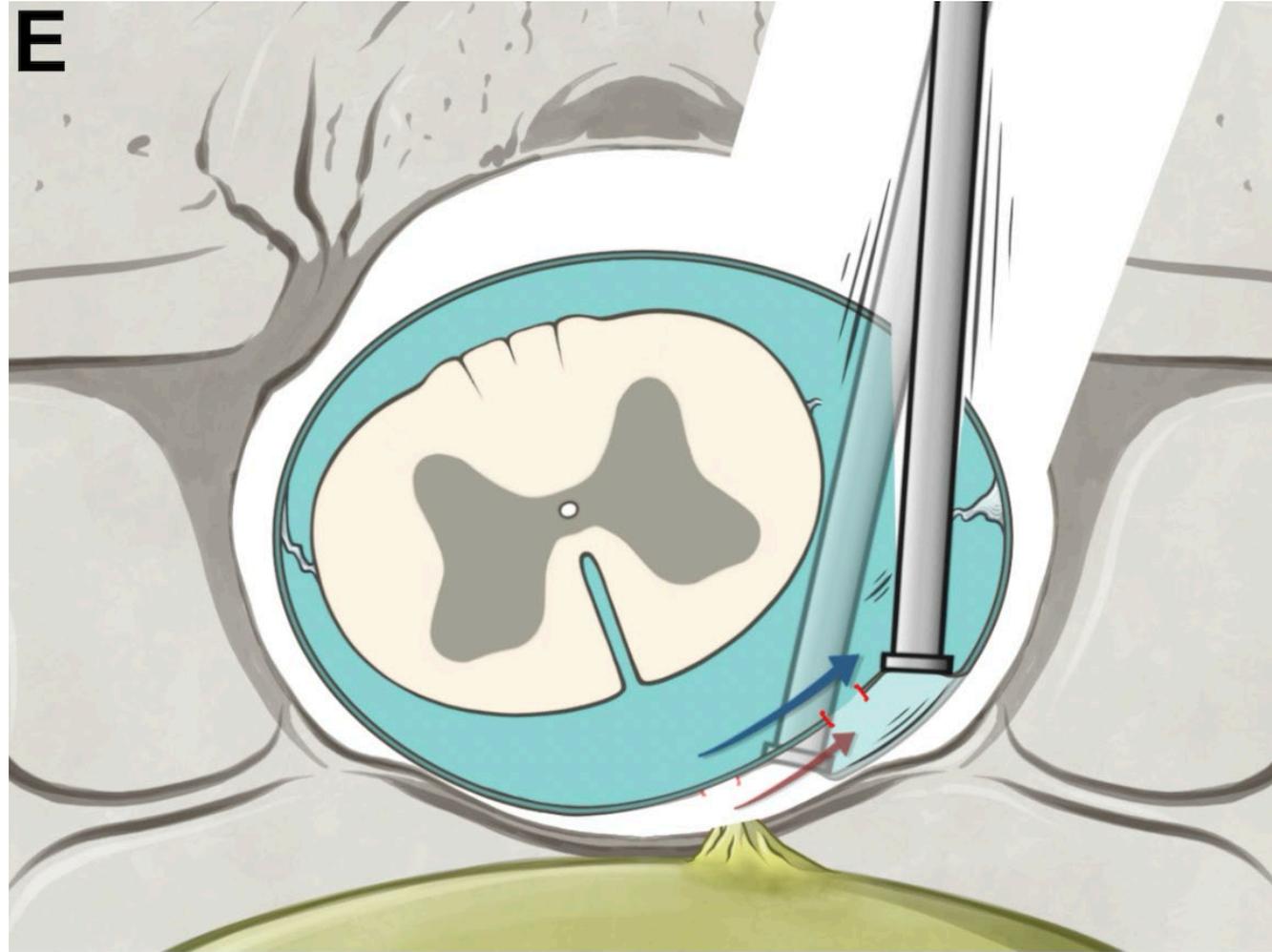


## Minimally invasive surgery for spinal cerebrospinal fluid leaks in spontaneous intracranial hypotension

Jürgen Beck, MD,<sup>1</sup> Ulrich Hubbe, MD,<sup>1</sup> Jan-Helge Klingler, MD,<sup>1</sup> Roland Roelz, MD,<sup>1</sup> Luisa Mona Kraus, MD,<sup>1</sup> Florian Volz, MD,<sup>1</sup> Niklas Lützen, MD,<sup>2</sup> Horst Urbach, MD,<sup>2</sup> Kristin Kieselbach, MD,<sup>3</sup> and Christian Fung, MD<sup>1</sup>

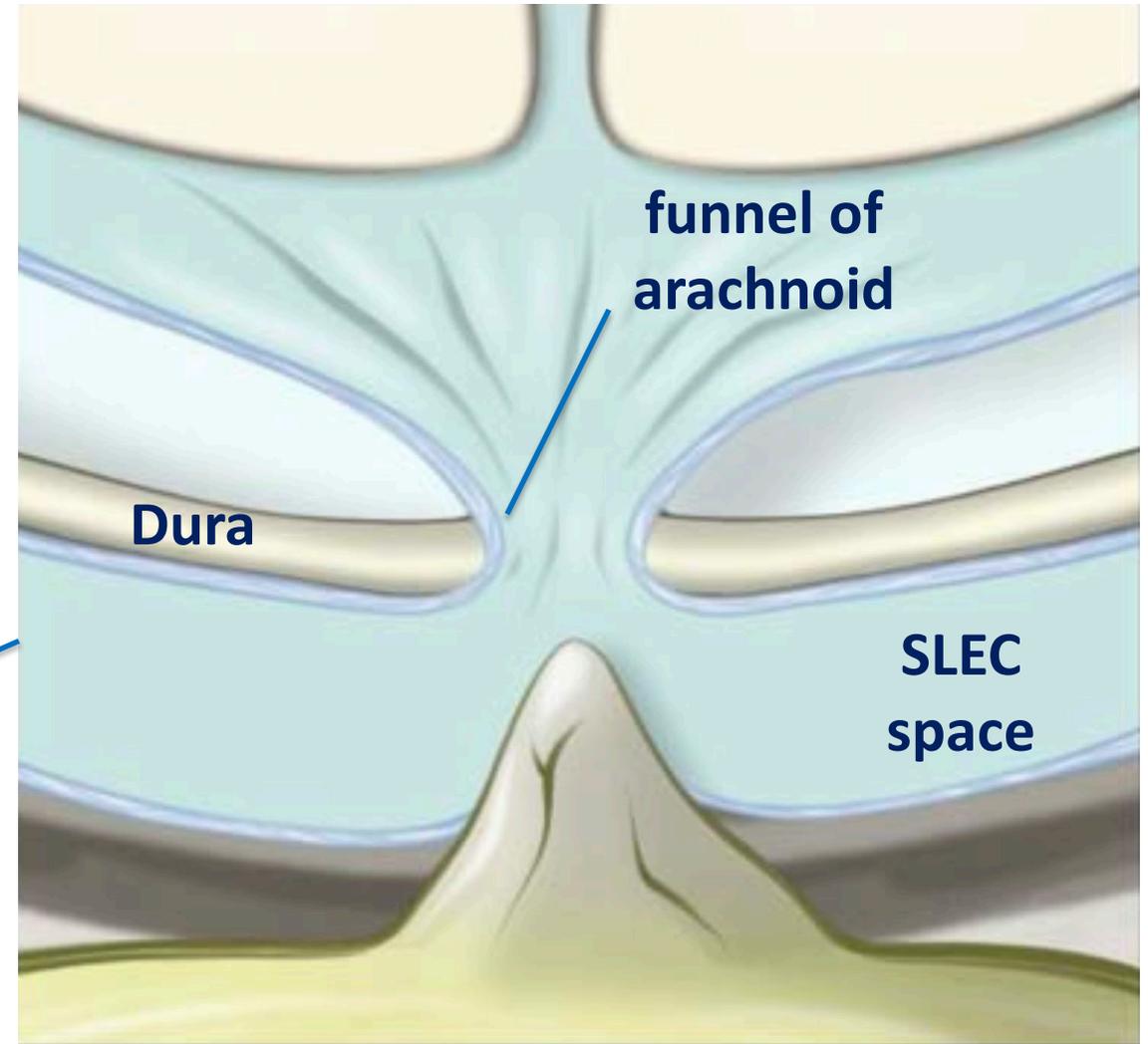
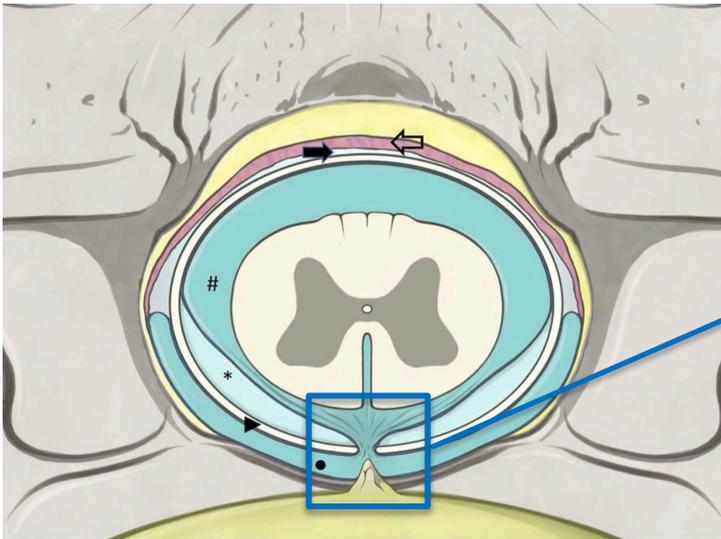
Departments of <sup>1</sup>Neurosurgery and <sup>2</sup>Neuroradiology, Medical Center, University of Freiburg, Freiburg; and <sup>3</sup>Interdisciplinary Pain Center, Medical Center, University of Freiburg, Freiburg, Germany



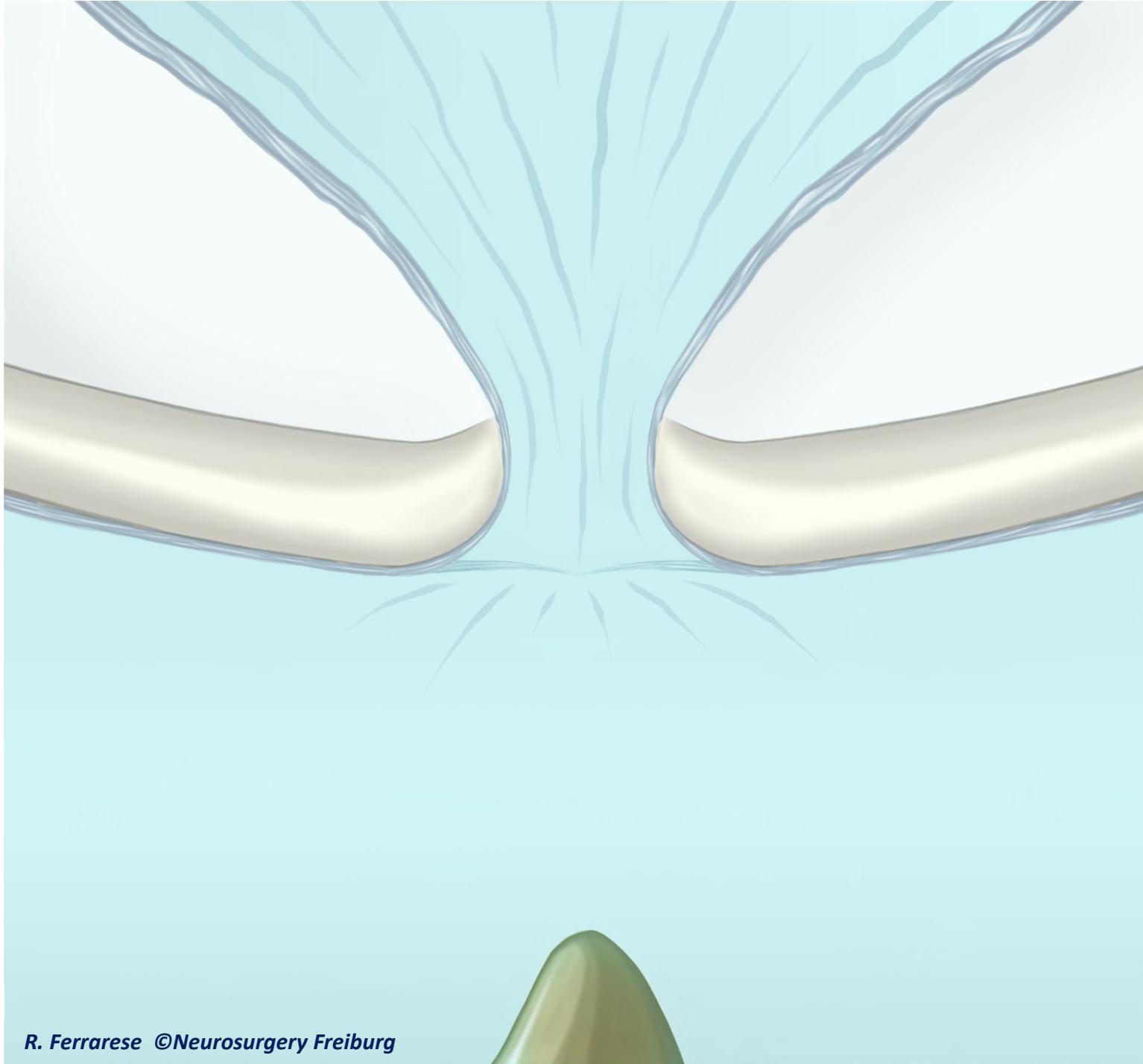


# Spinal cord surgery

# Microsurgical anatomy - transdural membranes



Häni et al. Beck Operative Neurosurgery 2023

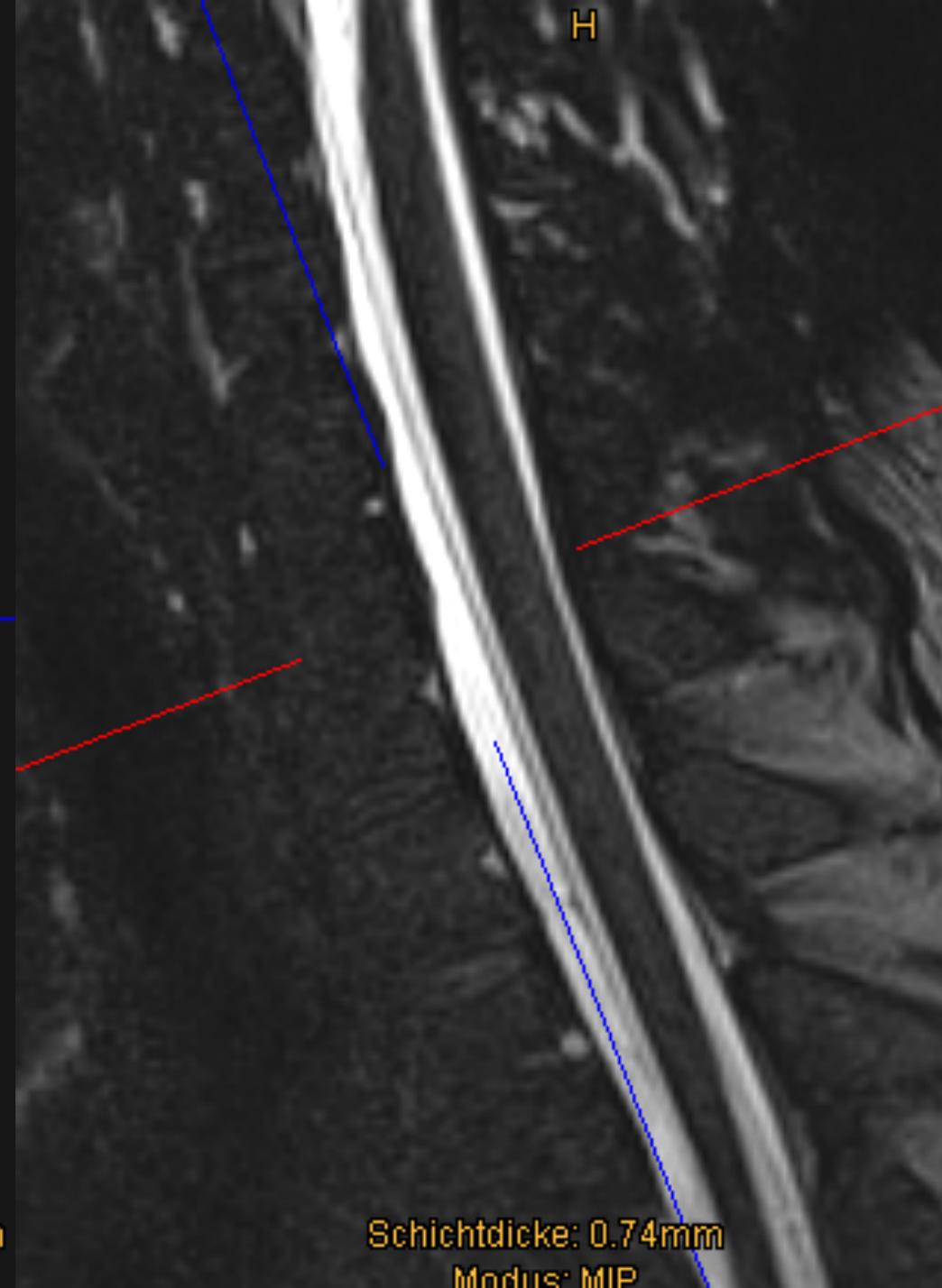


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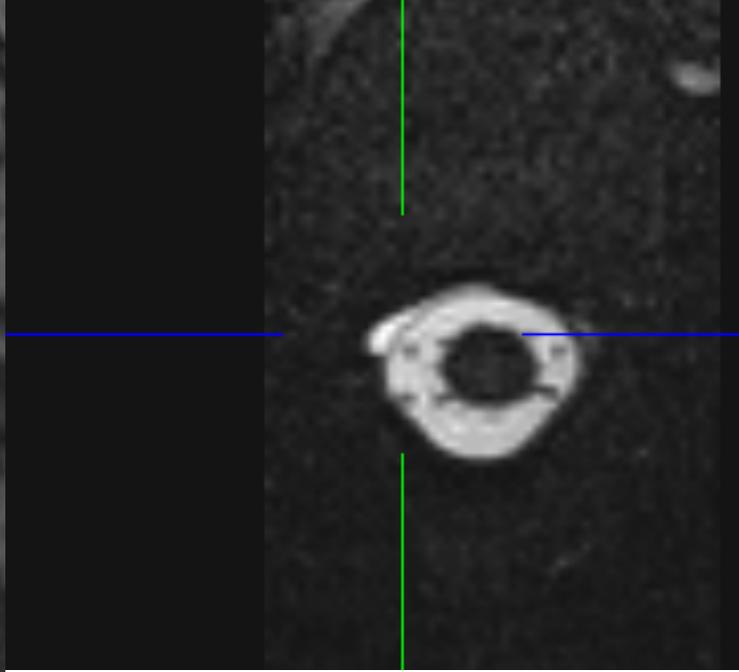
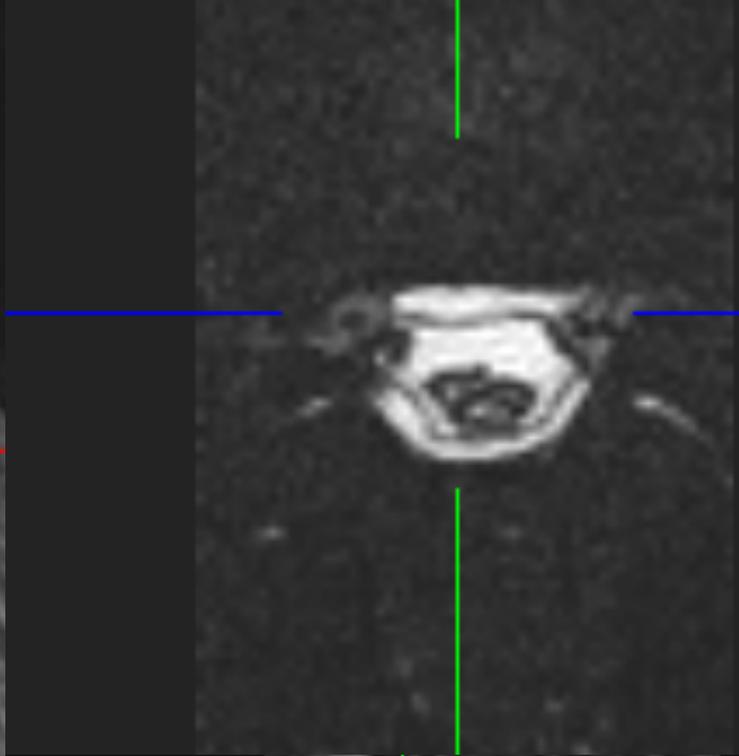


Schichtdicke: 0.72mm  
Modus: MIP

H



Schichtdicke: 0.74mm  
Modus: MIP



Ventral leak

Acute lateral leak

Chronic leak,  
Bibrachial amyotrophy

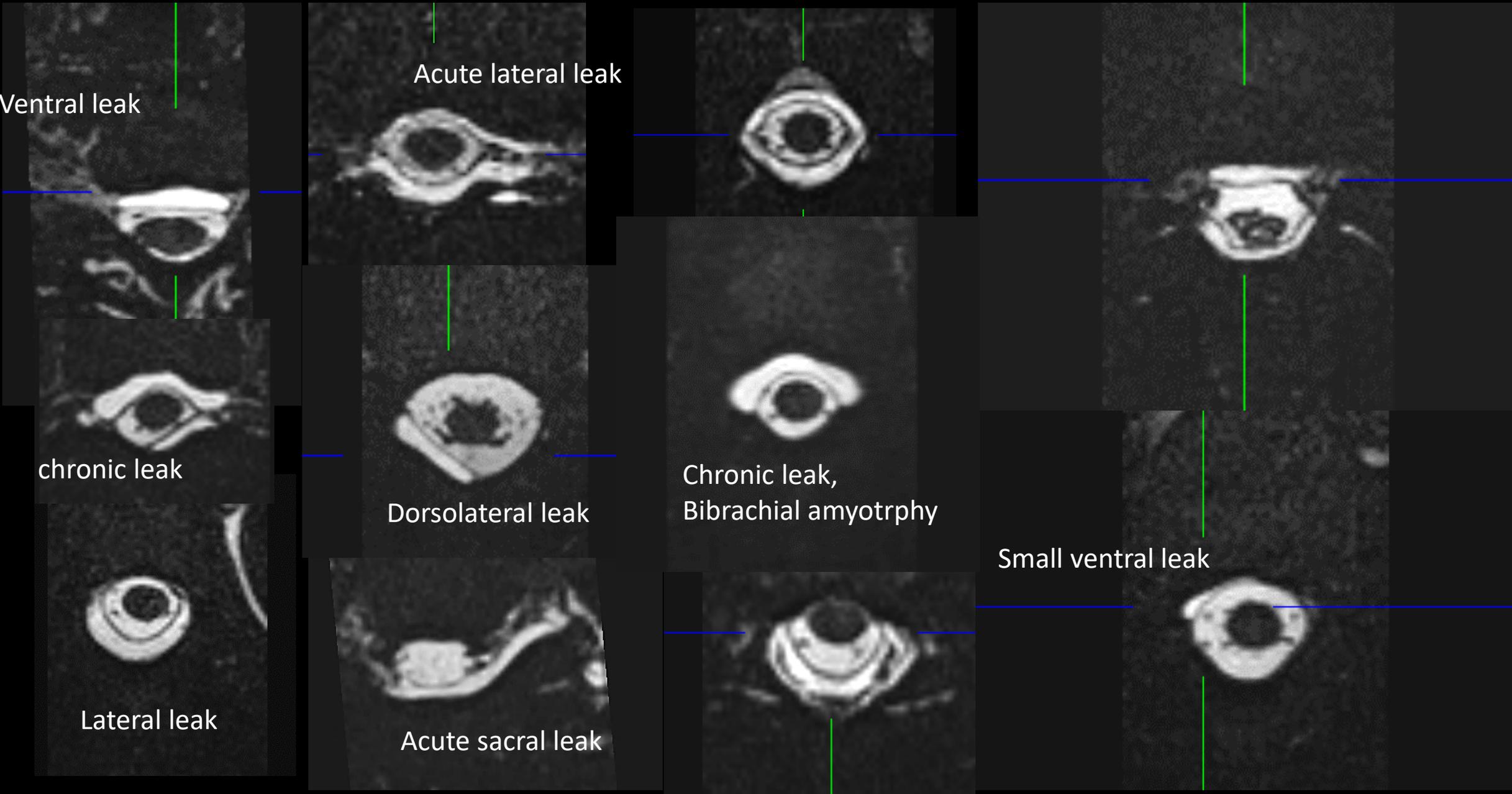
Small ventral leak

chronic leak

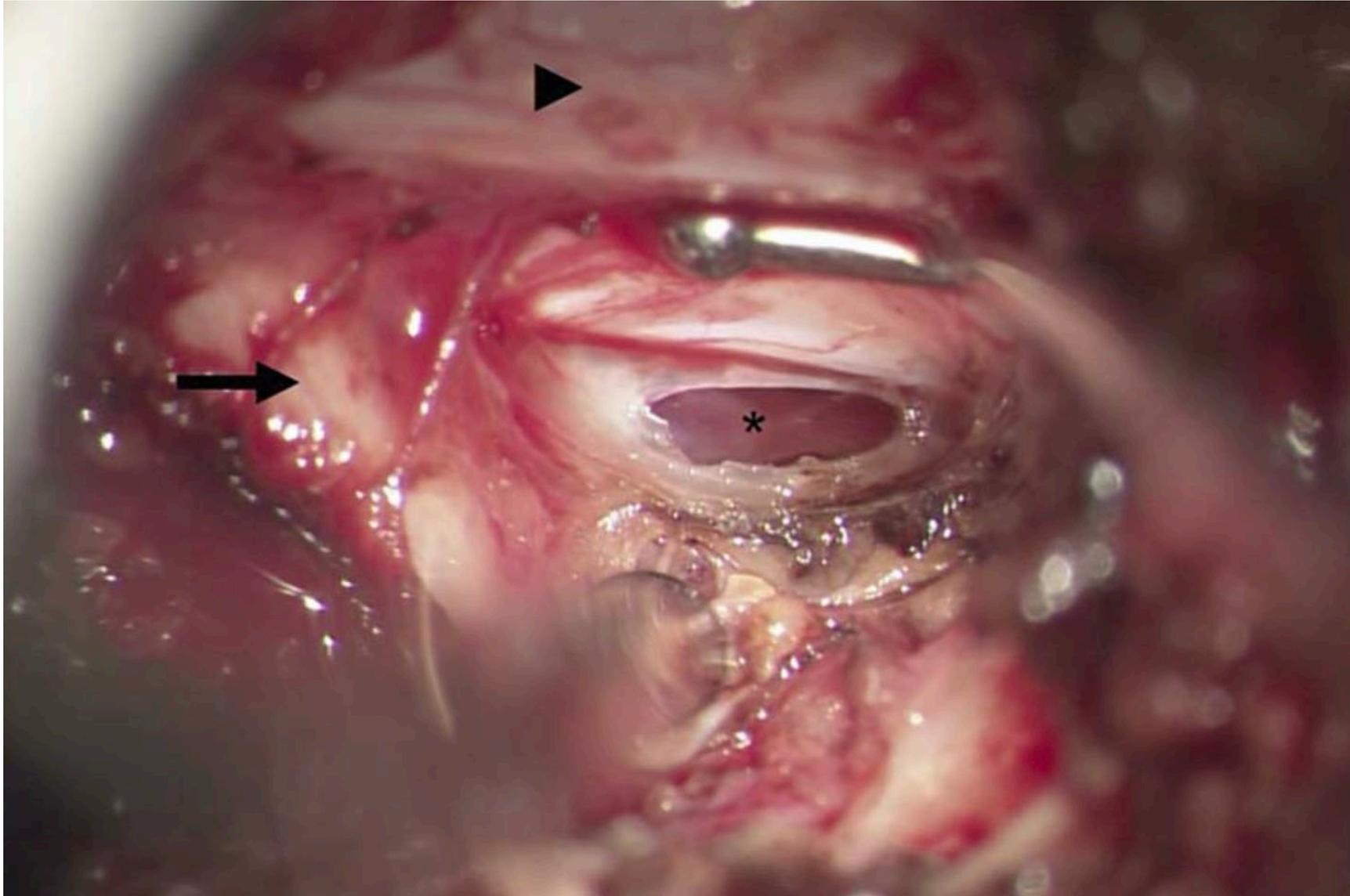
Dorsolateral leak

Lateral leak

Acute sacral leak



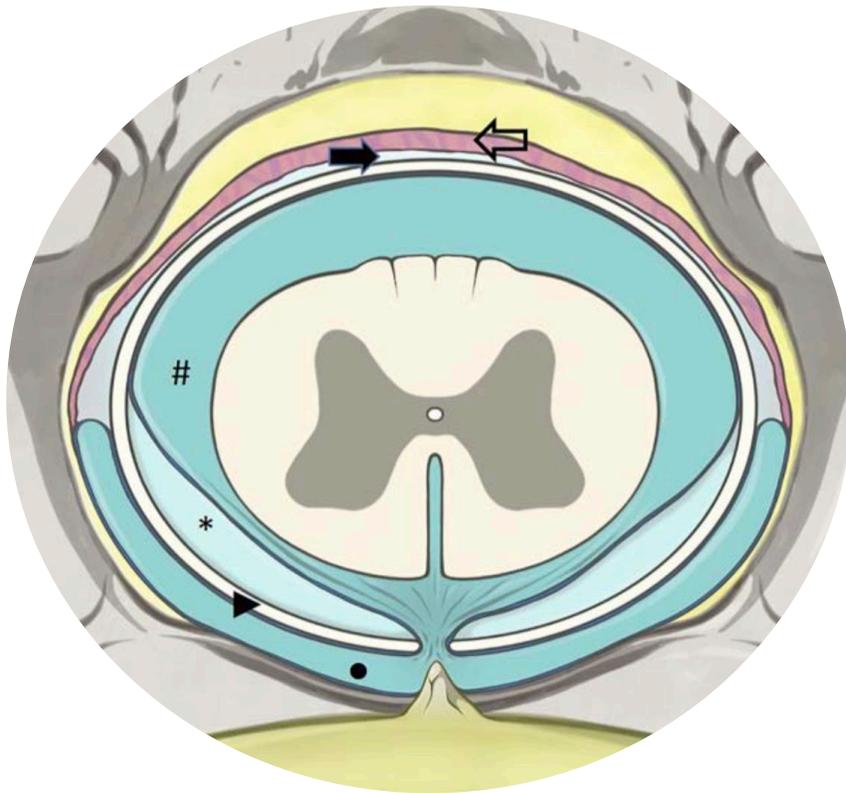
## Lateral membranes



OPEN

# Distinct Pattern of Membrane Formation With Spinal Cerebrospinal Fluid Leaks in Spontaneous Intracranial Hypotension

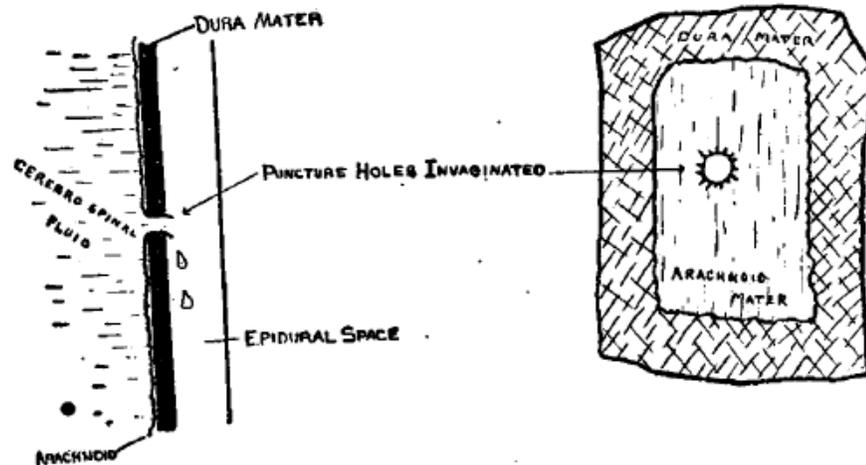
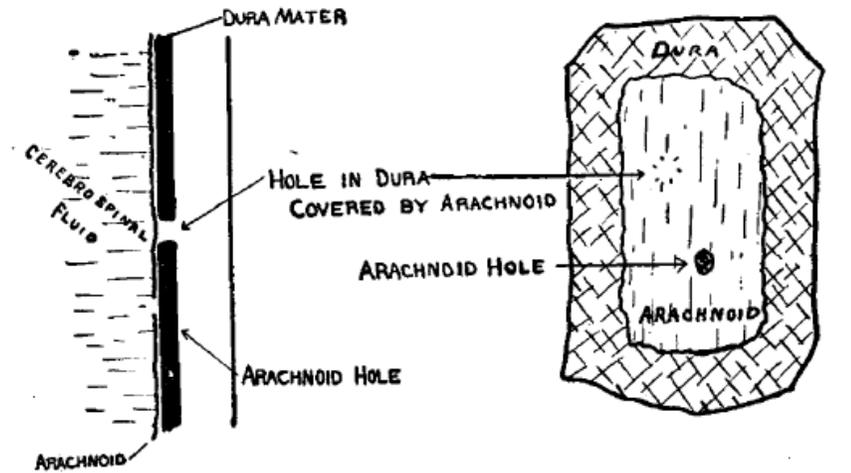
Levin Häni, MD  \*\*, Christian Fung, MD \*\*, Amir El Rahal, MD <sup>§</sup>, Florian Volz, MD †, Luisa Mona Kraus, MD †, Oliver Schnell, MD †, Roberto Ferrarese, PhD †, Daniel Erny, MD <sup>||</sup>, Marius Schwabenland, MD <sup>§</sup>, Horst Urbach, MD <sup>¶</sup>, Niklas Lützen, MD <sup>¶</sup>, Jürgen Beck, MD †



- Paramount importance for diagnosis and treatment

... all about membranes

# The cause of lumbar puncture headache - 1918



## THE CAUSE OF LUMBAR PUNCTURE HEADACHE

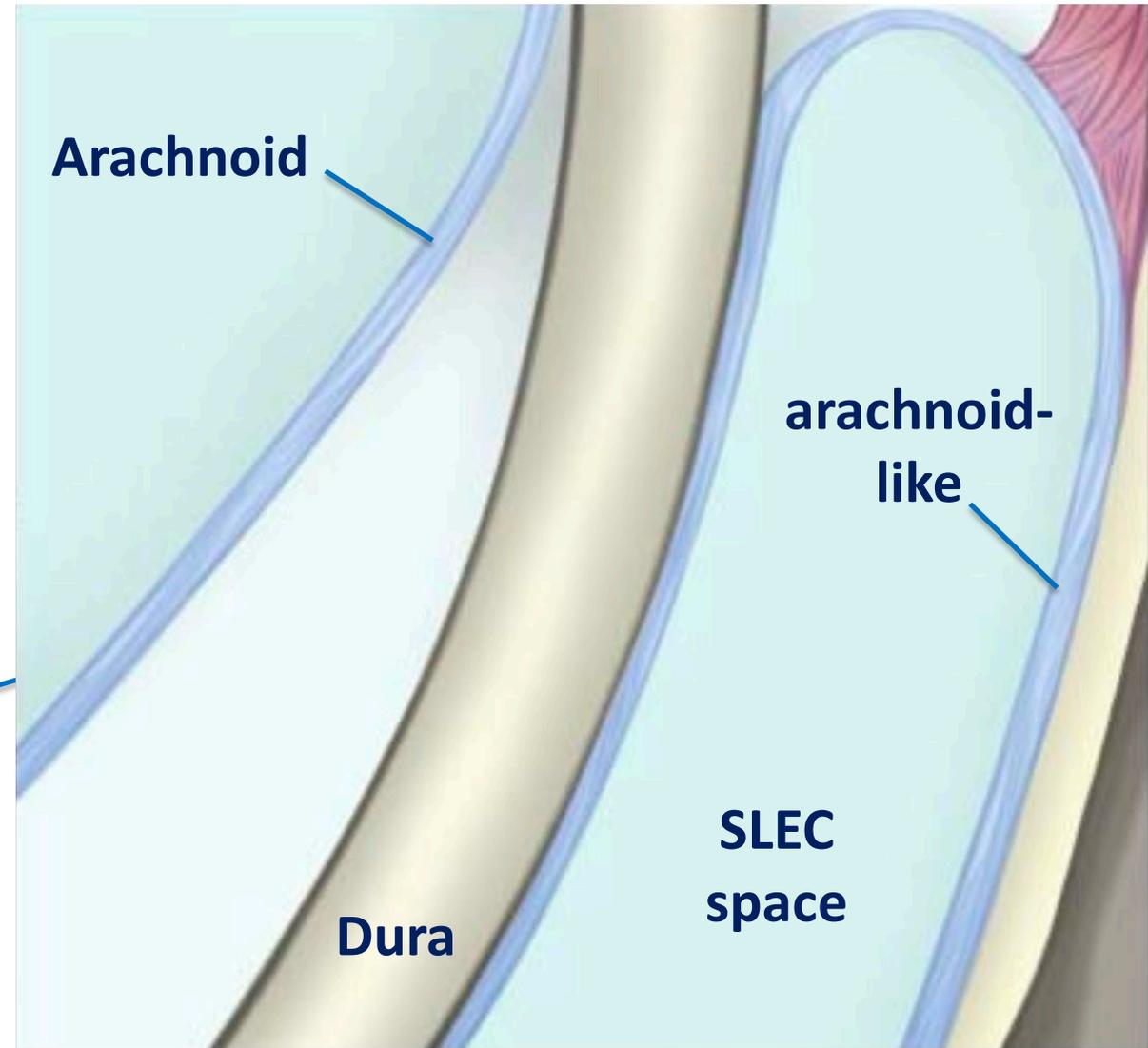
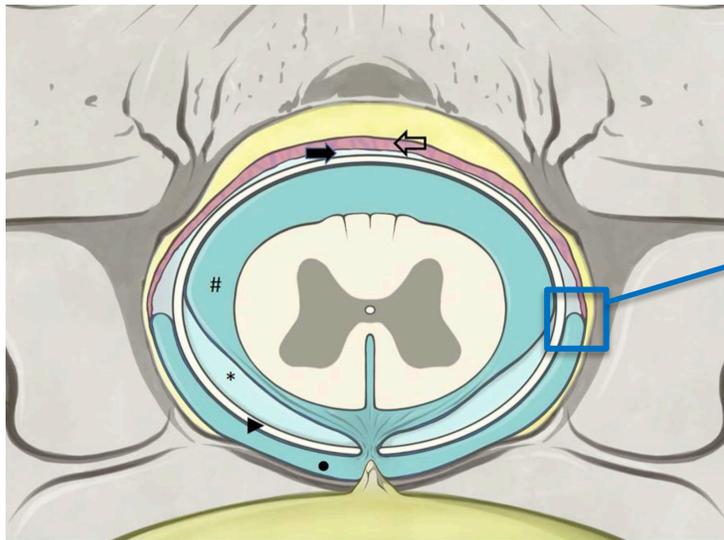
RUSSELL G. MACROBERT, M.B. (TOR.)

Associate Physician, Neurological Institute

NEW YORK

JOUR. A. M. A.  
MAY 11, 1918

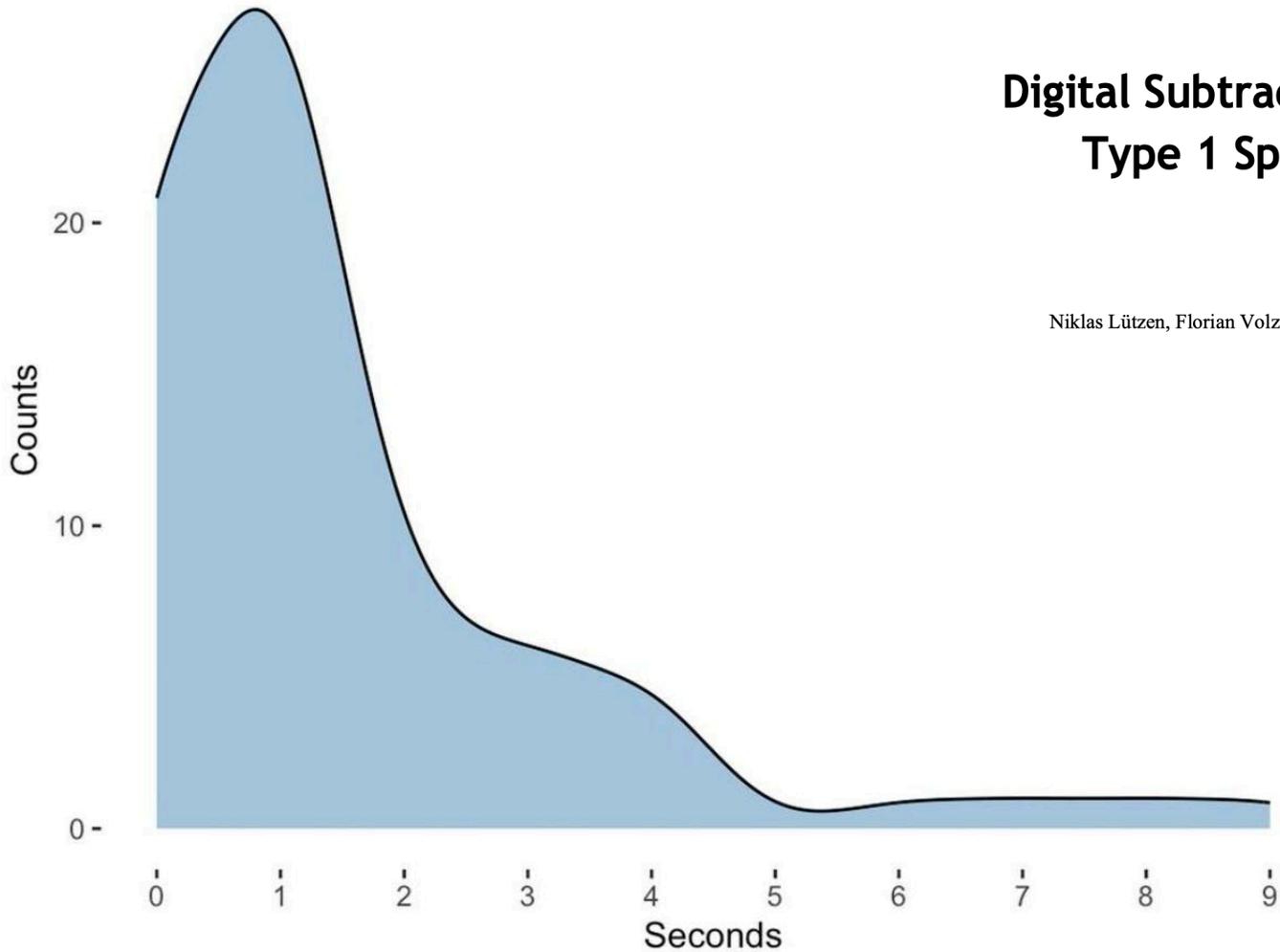
# Microsurgical anatomy - lateral membranes





**Flow-void**  
=  
***Lalani-sign***

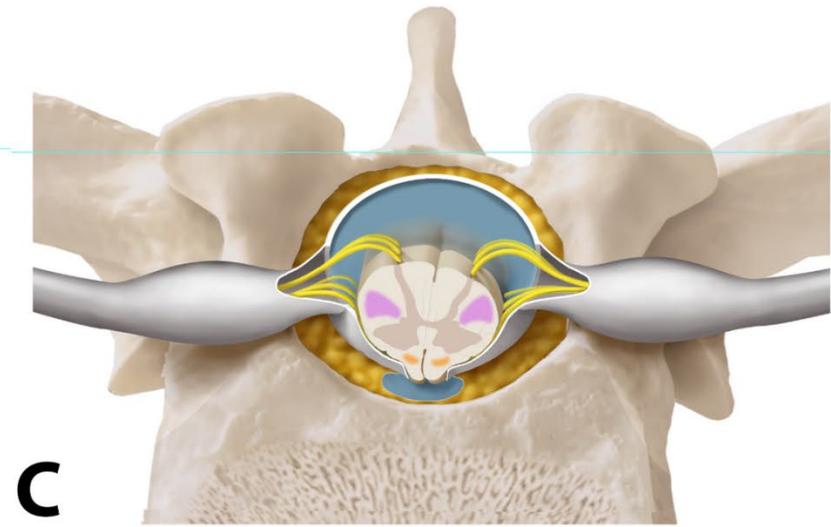
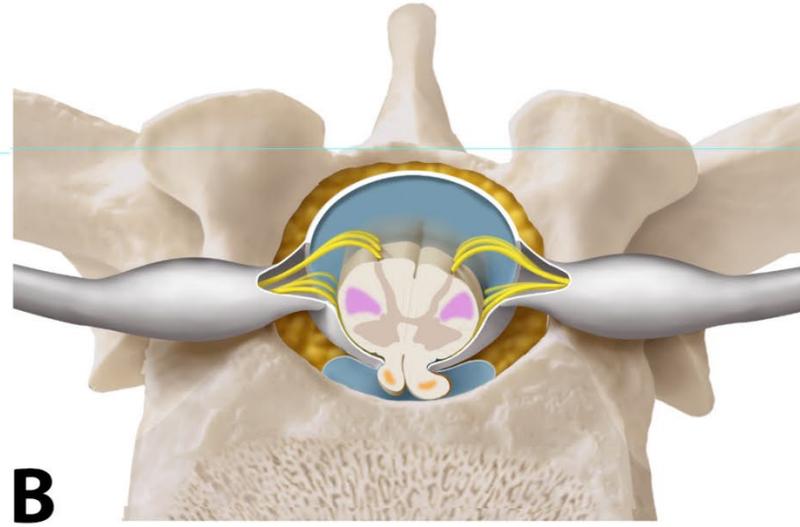
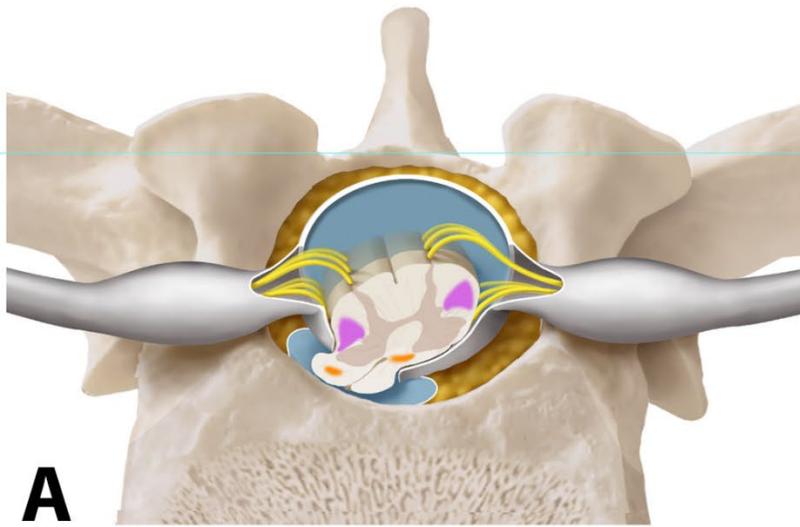
### Temporal dynamics



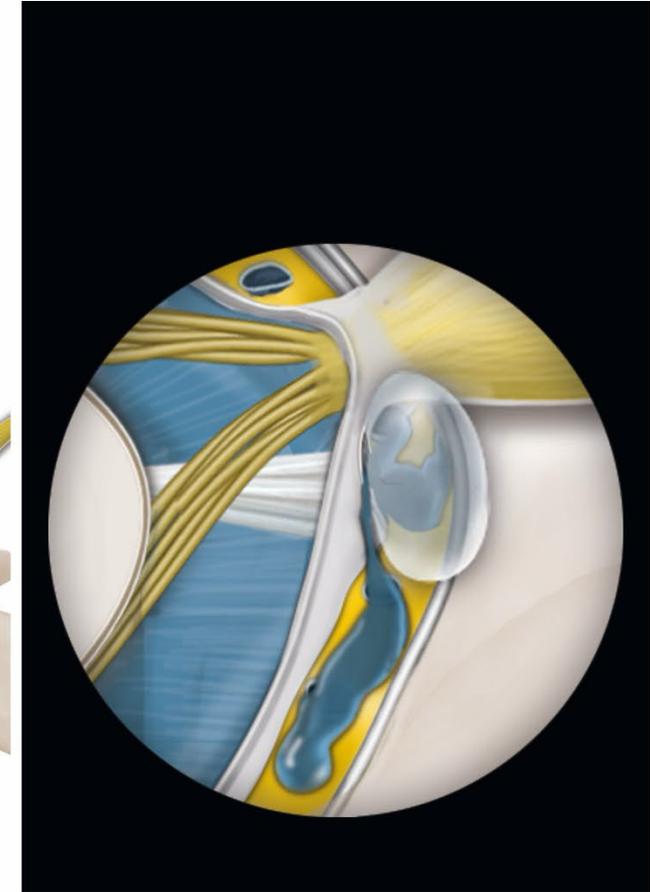
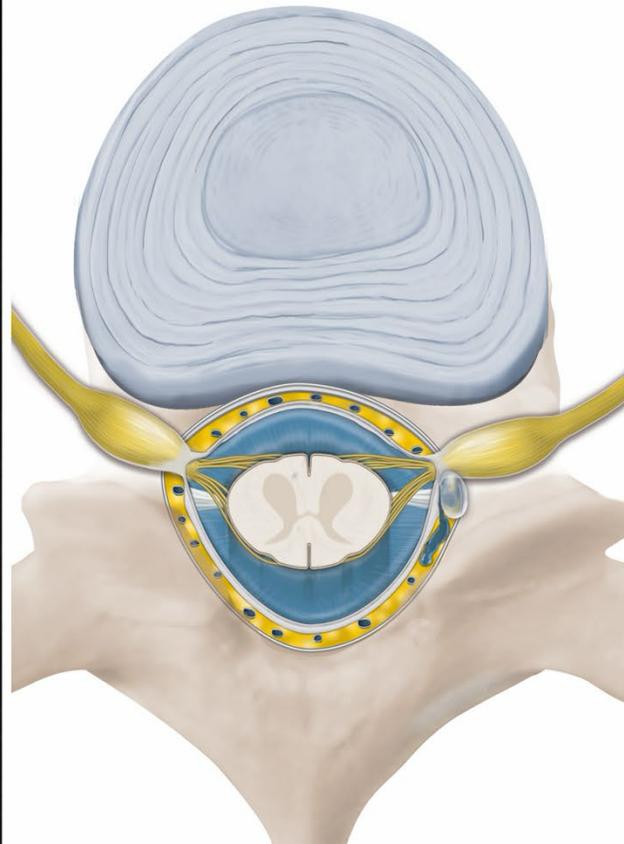
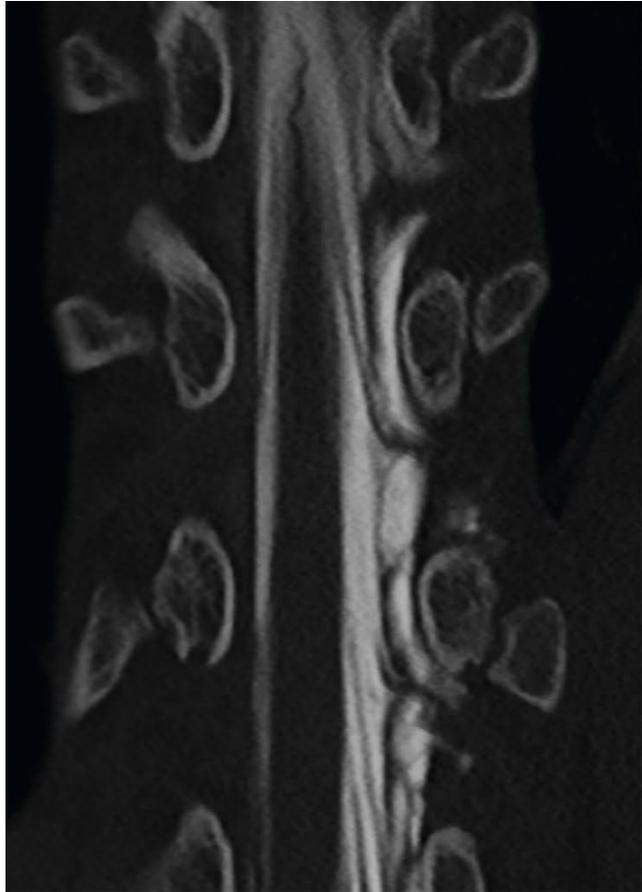
## Digital Subtraction Myelography for the Detection of Type 1 Spinal CSF Leaks: Evaluation of Temporal Characteristics and Diagnostic Value

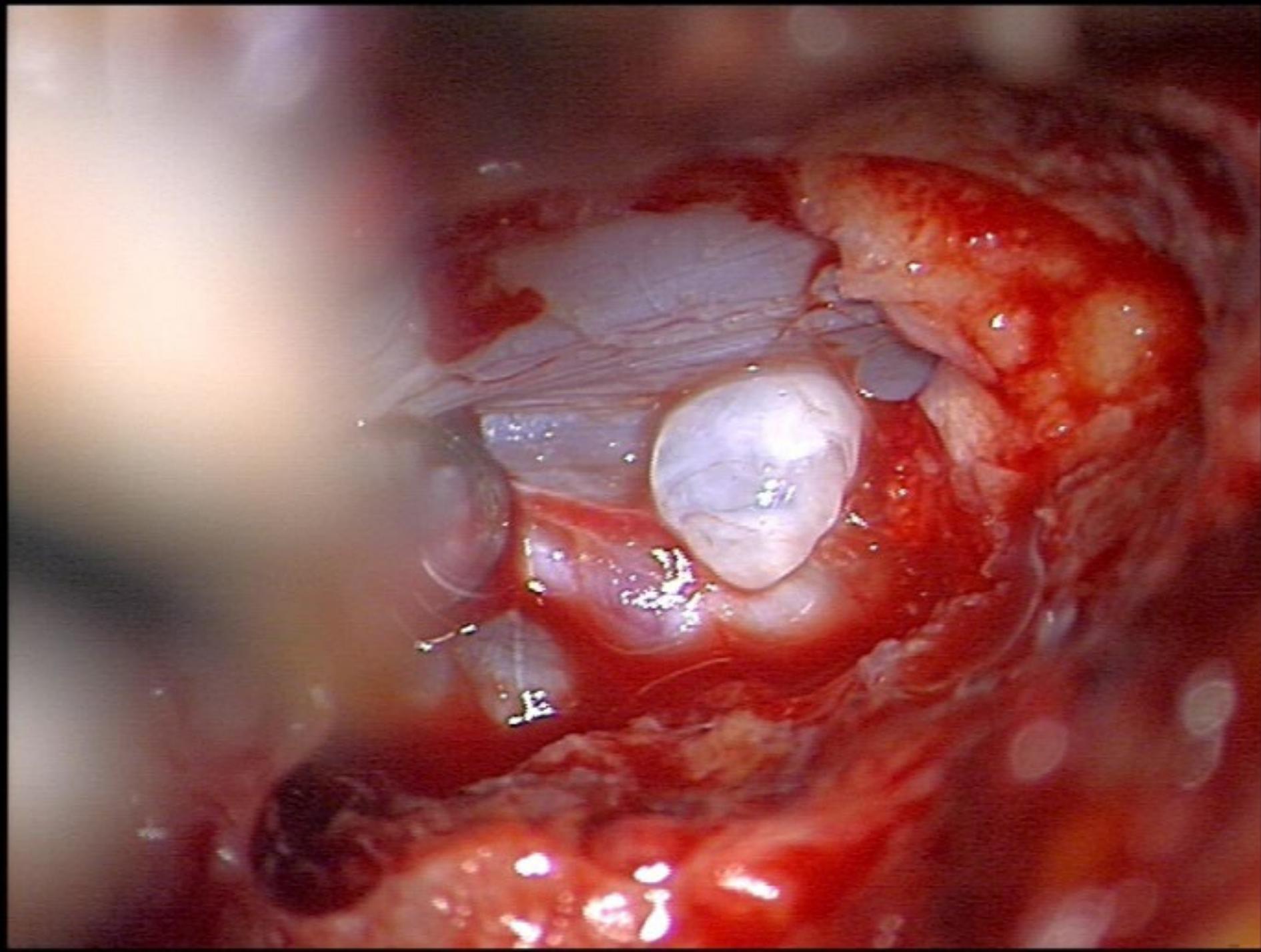
Niklas Lützen, Florian Volz, Amir El Rahal, Katharina Wolf, Laura Krismer, Jürgen Beck, Horst Urbach, Charlotte Zander

# Idiopathic ventral spinal cord herniation

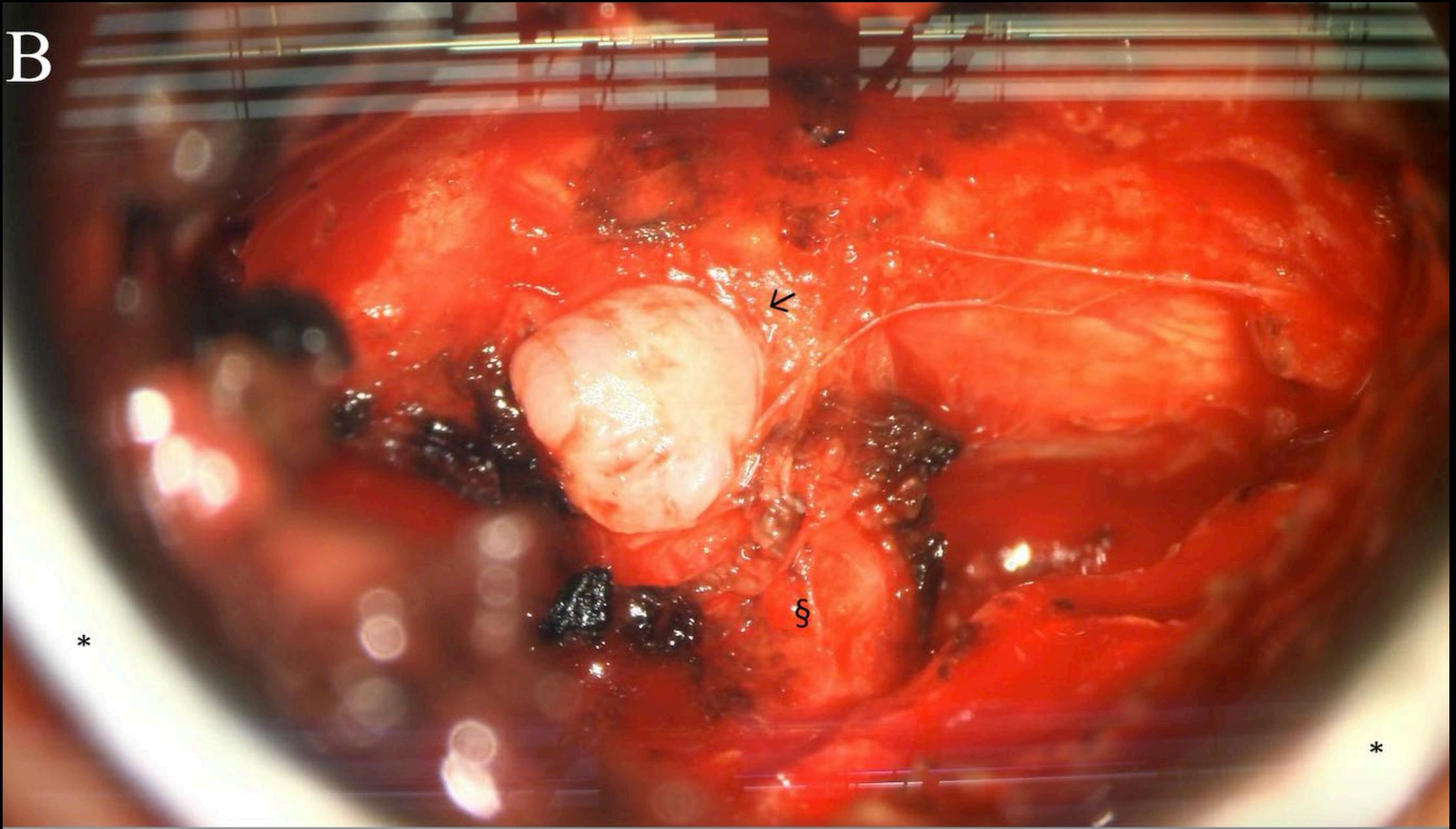


# Spinal meningeal diverticula (cyst)

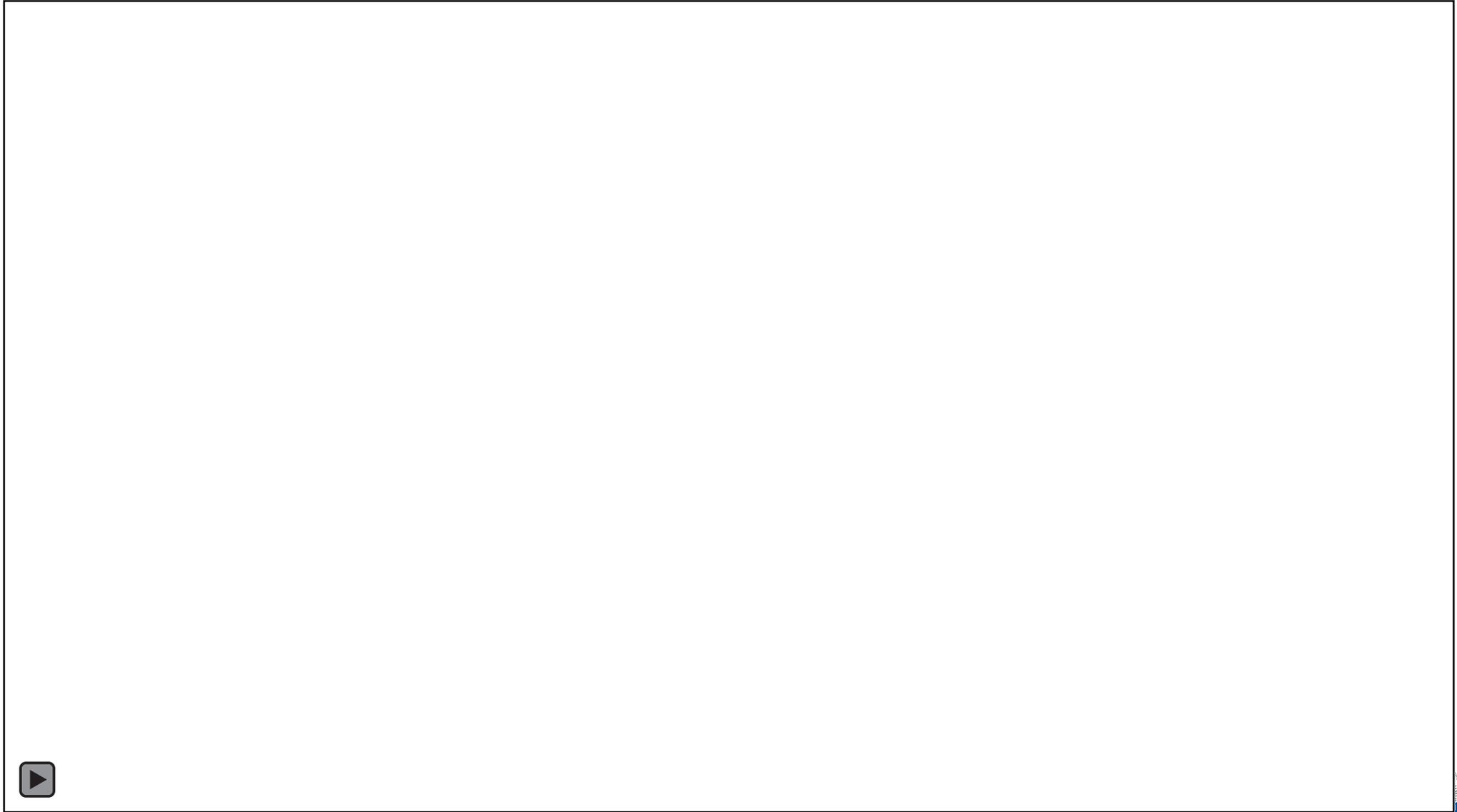




B



# Surgical Technique



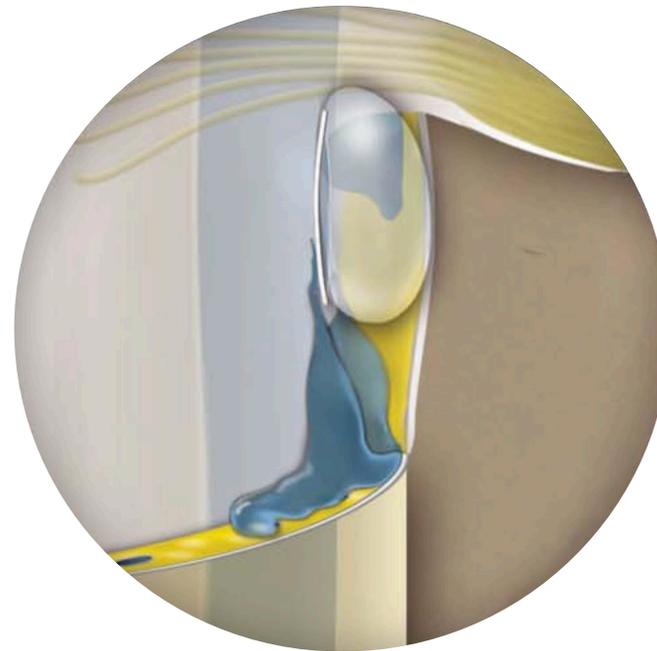
## What is the nature and cause of the CSF leak?

The nature of the leak: a longitudinal slit in the dura

longitudinal slit in the axilla of the nerve root,



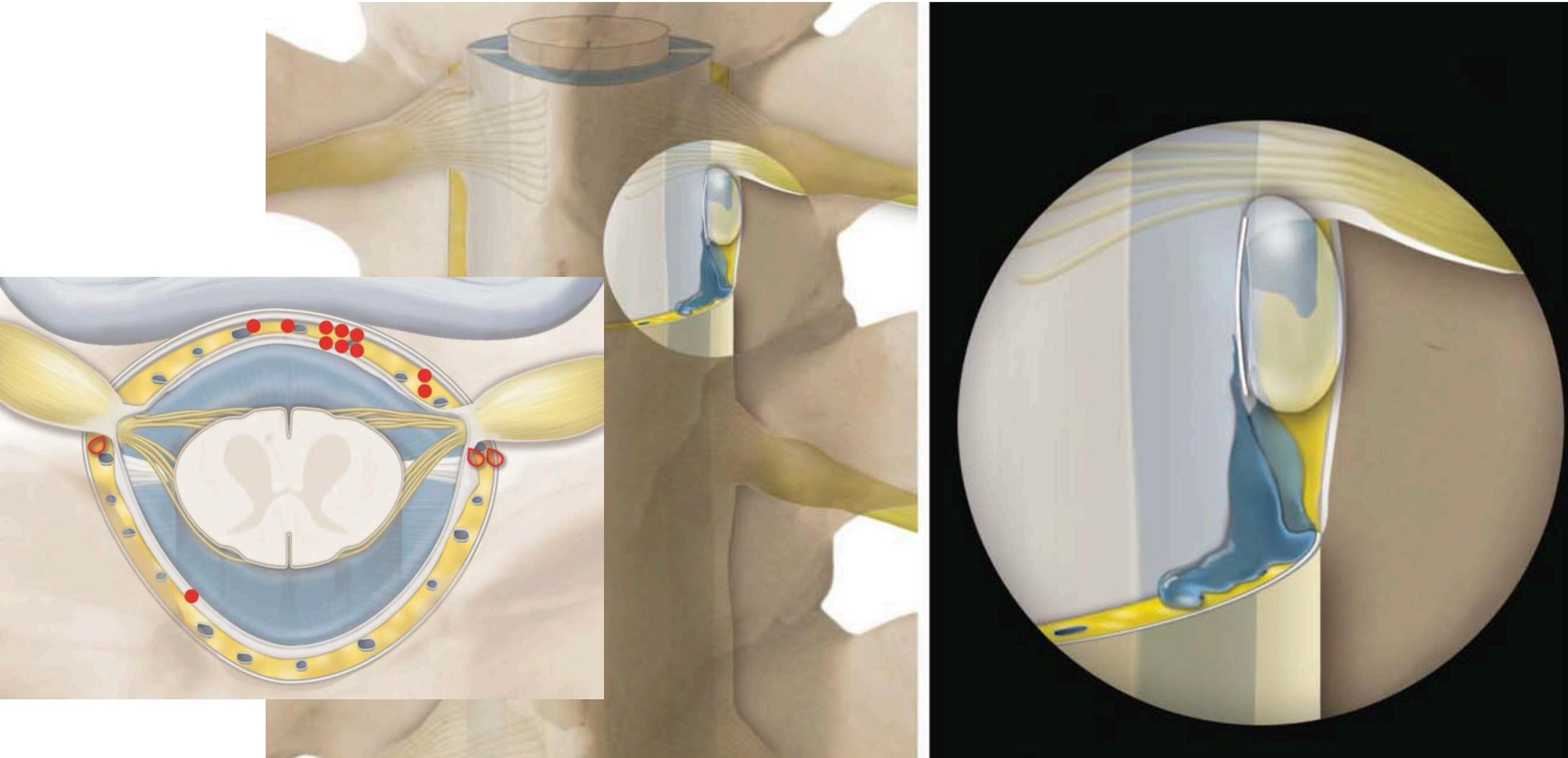
September 20, 2016  
Beck et al. Neurology



„... CSF leakage from **dural tears** but not through the **arachnoidal diverticula**”

“Rather than acting as a source of CSF leakage, the **herniated arachnoid** appeared to seal the tear (insufficiently)... “

*Beck et al. Neurology 2016*

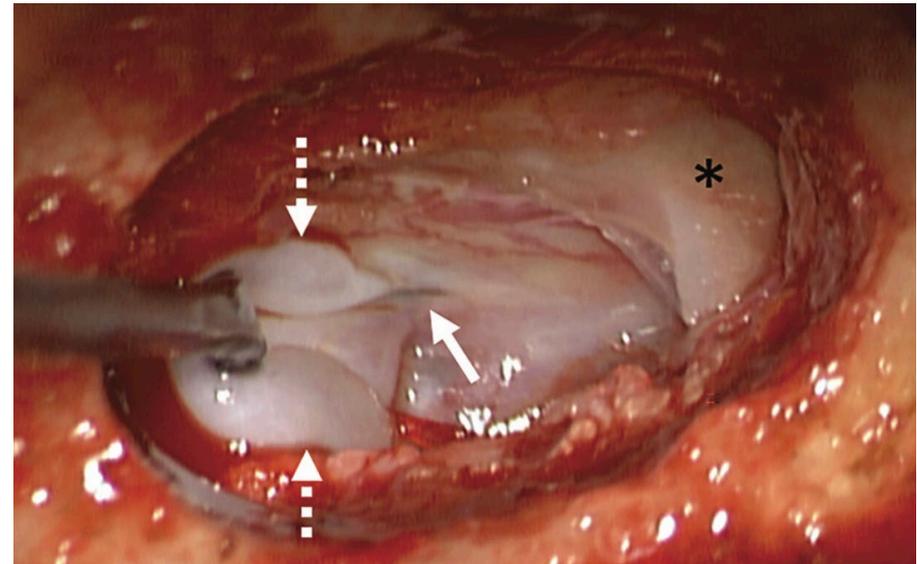


# Expounding on the Distinction between Lateral Dural Tears and Leaking Meningeal Diverticula in Spontaneous Intracranial Hypotension

LETTERS

“... the arachnoid diverticulum is a secondary manifestation of the lateral dural tear and not the source of CSF leak.”

“The actual site of CSF leak was from the edges of the dural tear itself (solid arrow) rather than the diverticulum. “



Pedicle

Nerve root sleeve

Thecal sac

Disc

Pedicular leak type

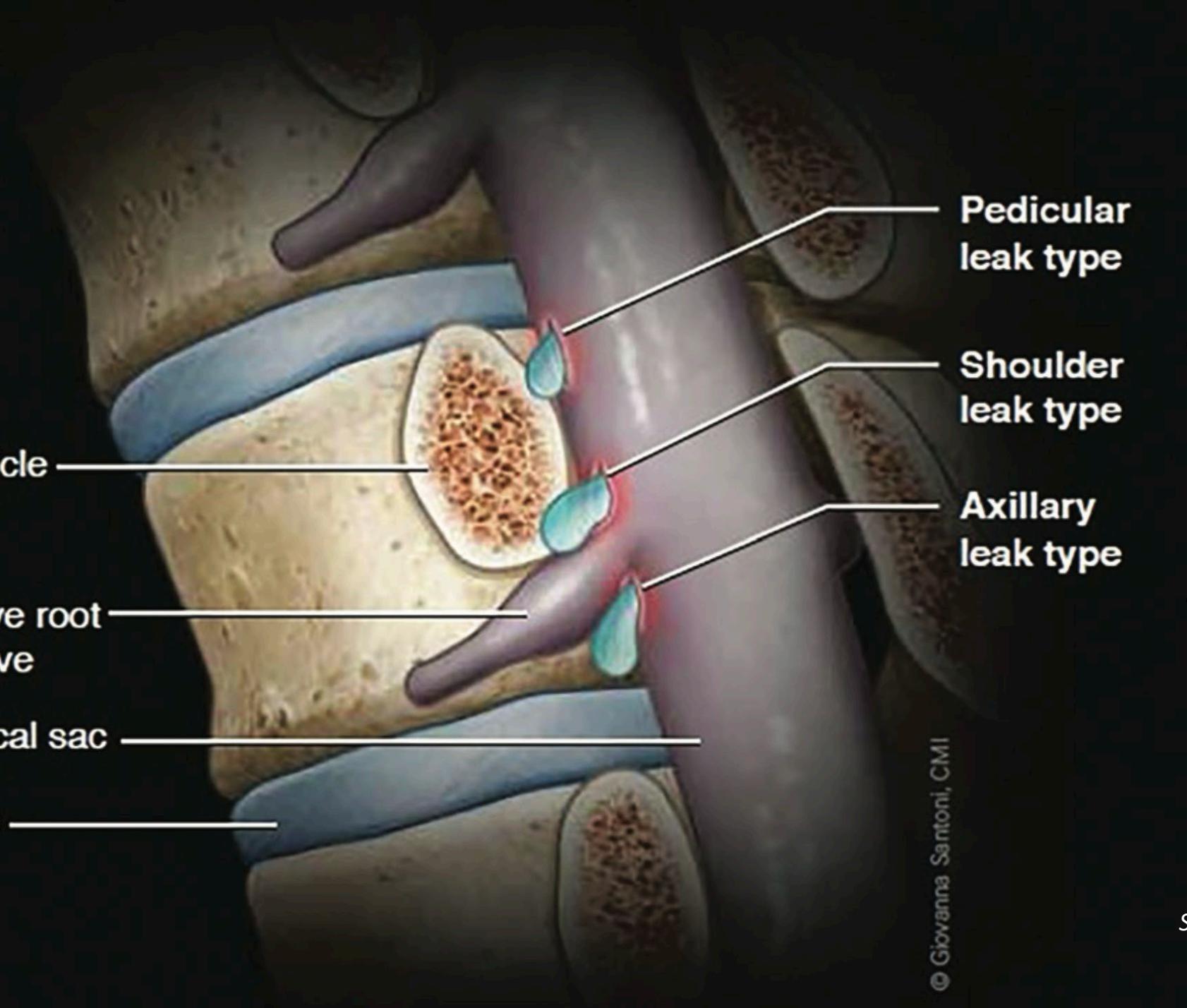
Shoulder leak type

Axillary leak type

93 %

© Giovanna Santoni, CMI

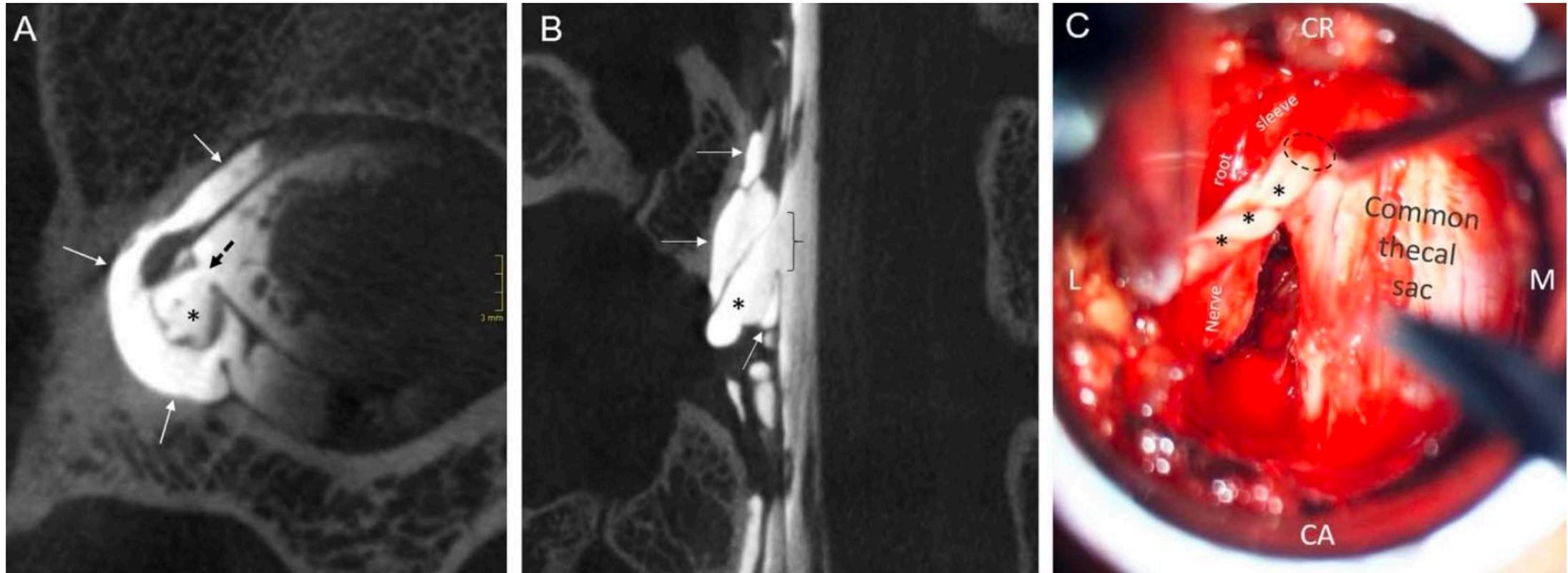
Schievink et al. AJNR 2024



# Advanced Imaging of Type 2 Spinal CSF Leaks with Ultrahigh-Resolution Cone-Beam CT Myelography

AJNR

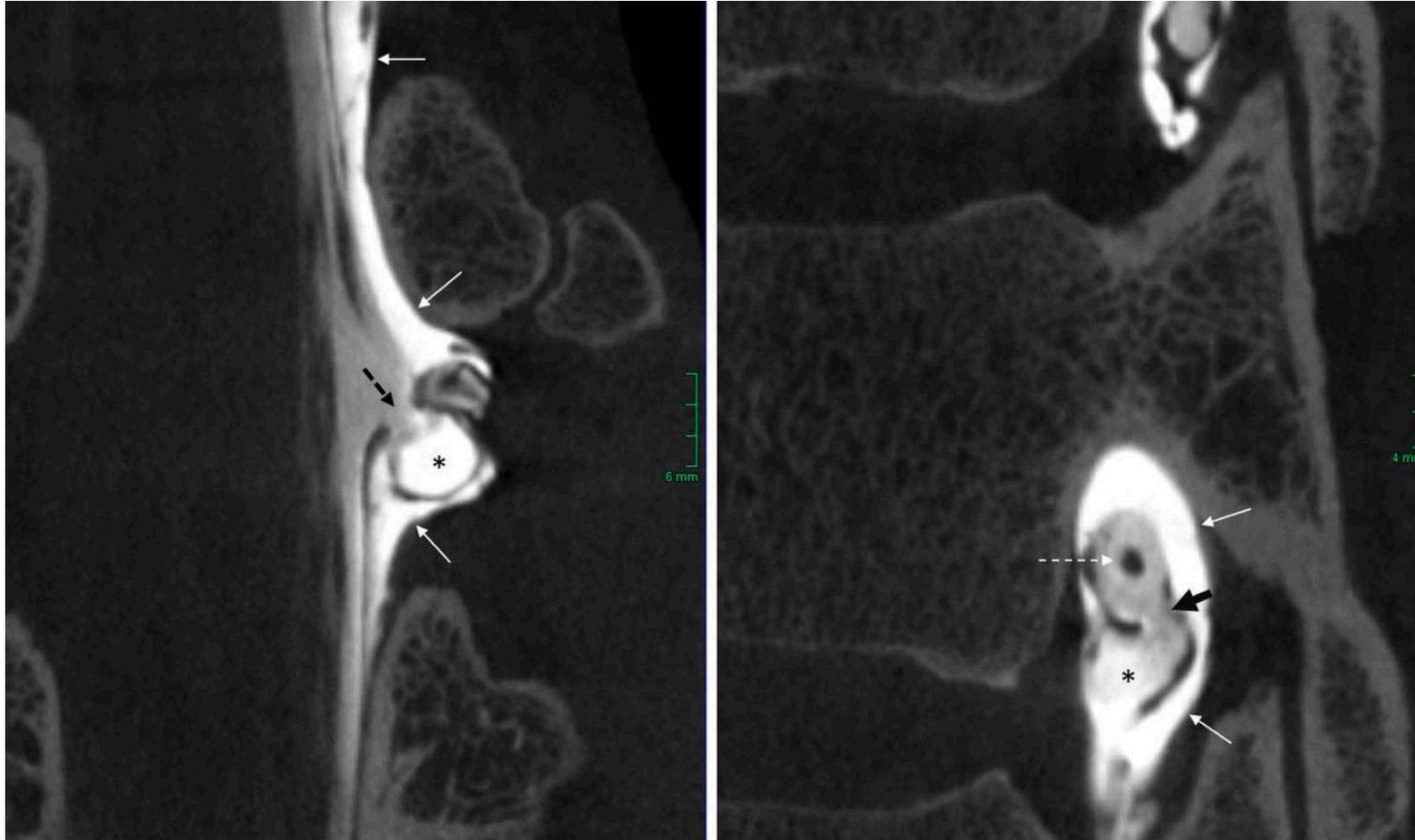
Niklas Lützen, Charlotte Zander, Jürgen Beck, Florian Volz, Katharina Wolf, Amir El Rahal, Horst Urbach



# Advanced Imaging of Type 2 Spinal CSF Leaks with Ultrahigh-Resolution Cone-Beam CT Myelography

AJNR

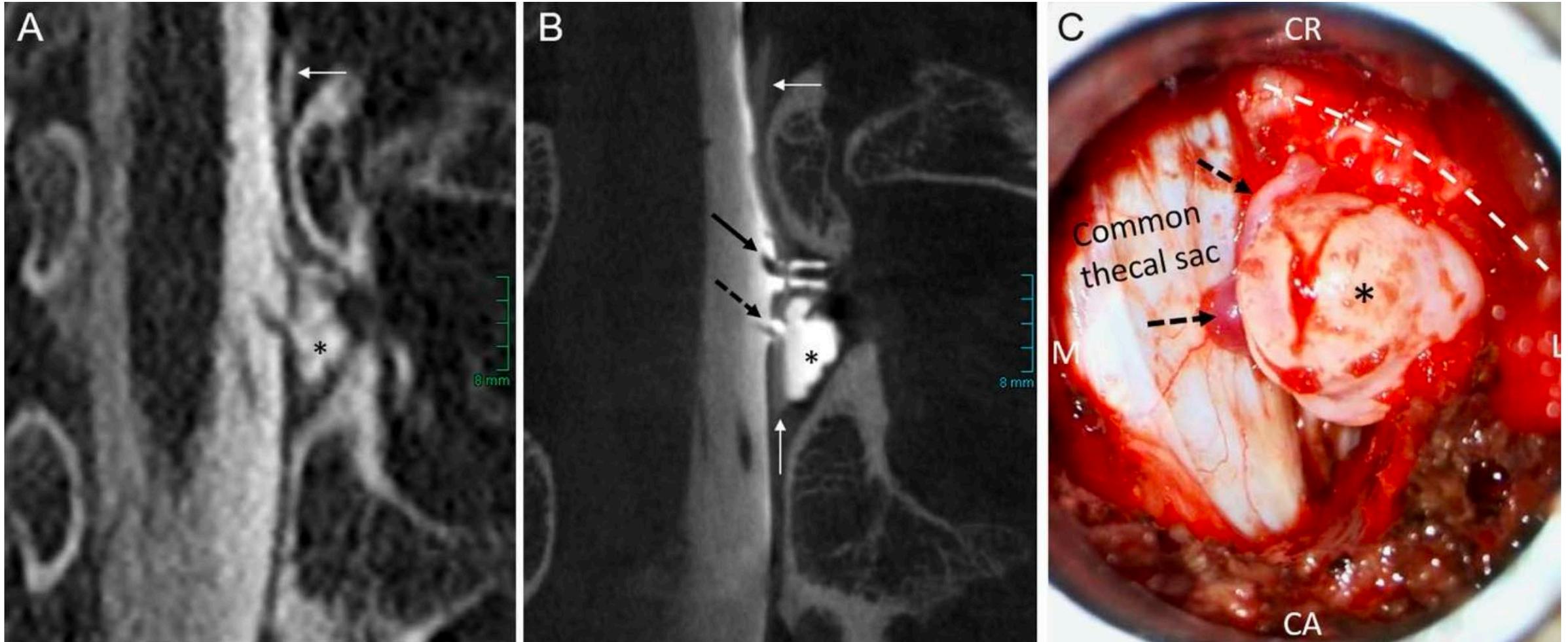
Niklas Lützen, Charlotte Zander, Jürgen Beck, Florian Volz, Katharina Wolf, Amir El Rahal, Horst Urbach

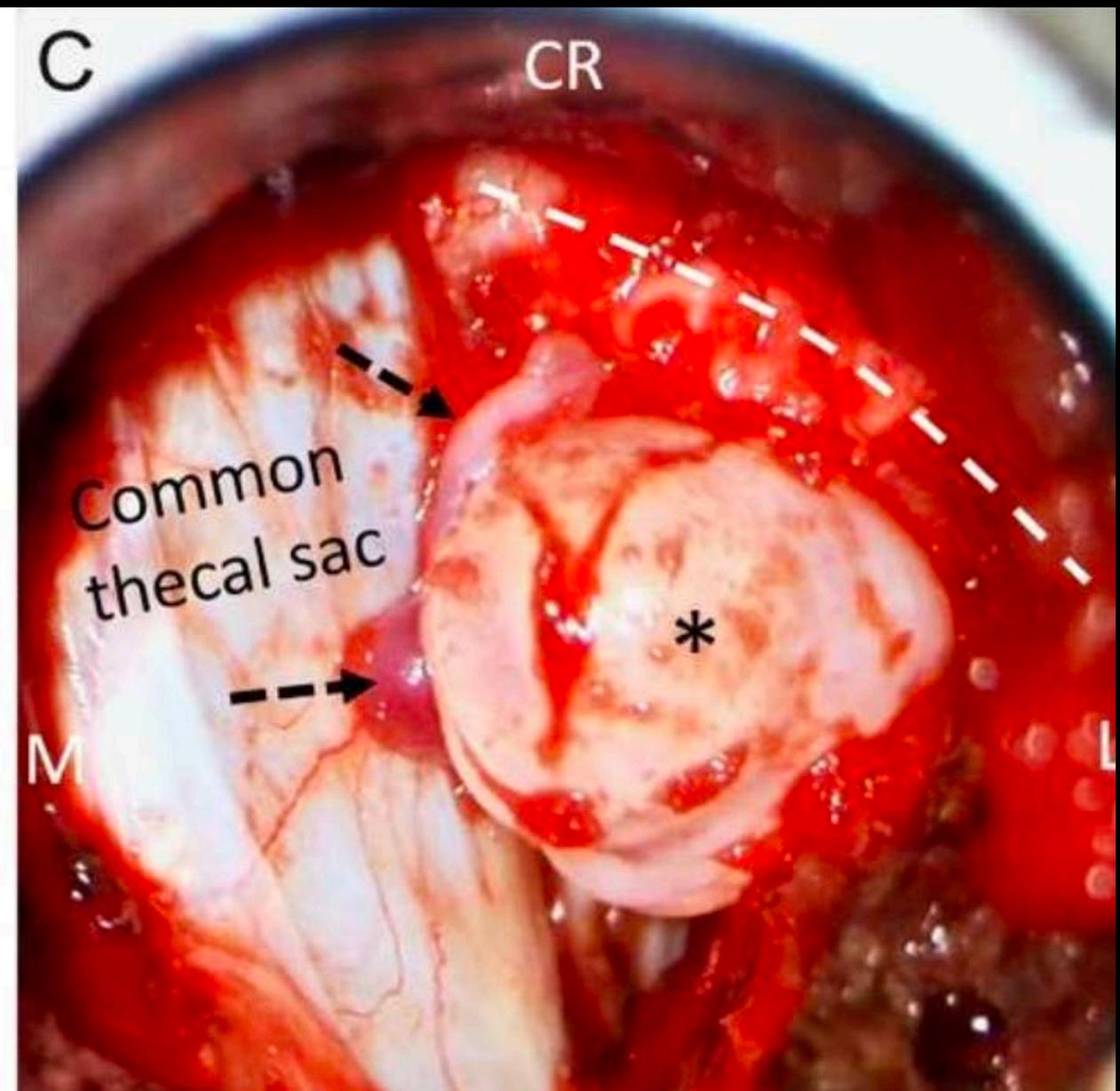
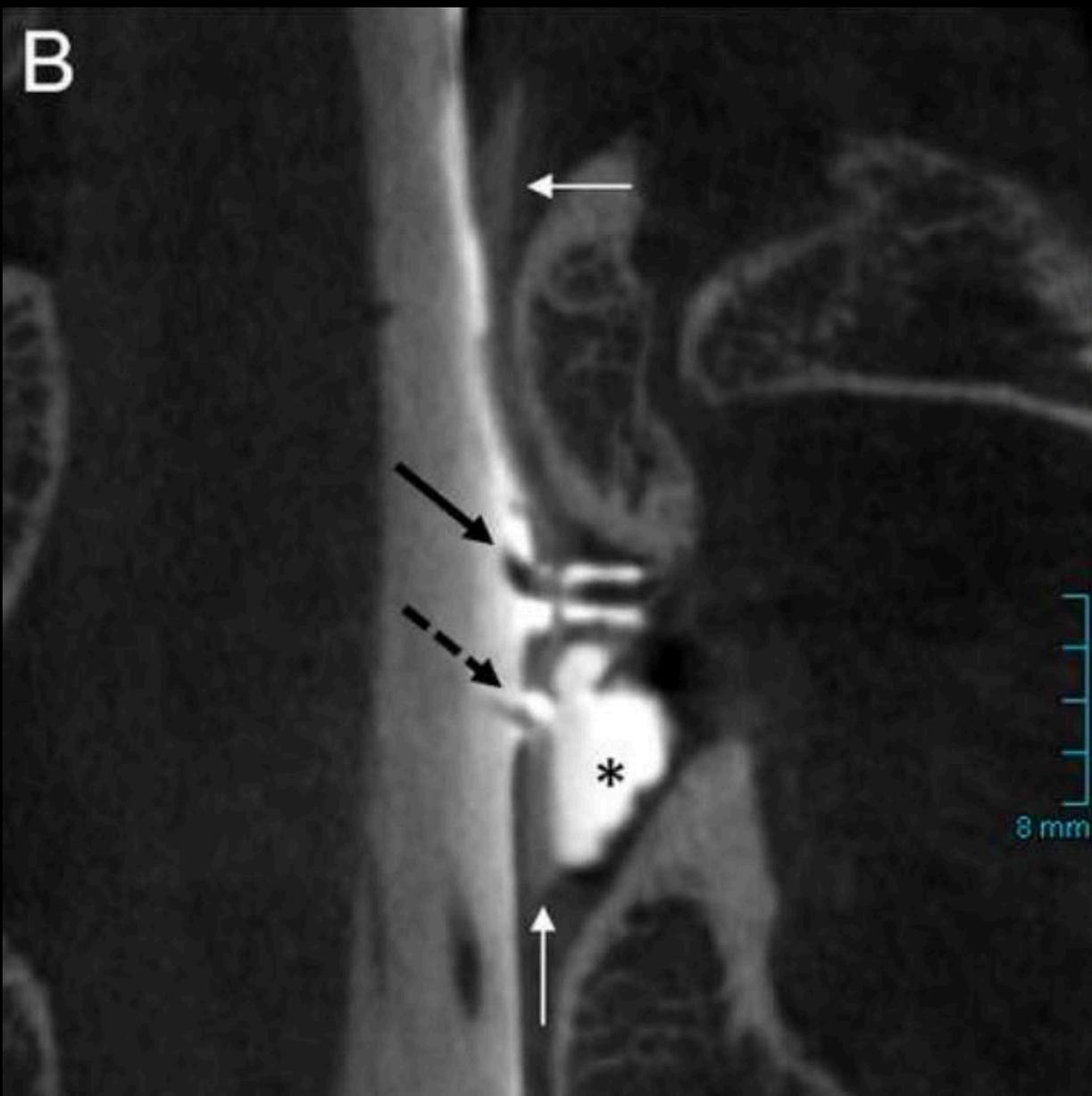


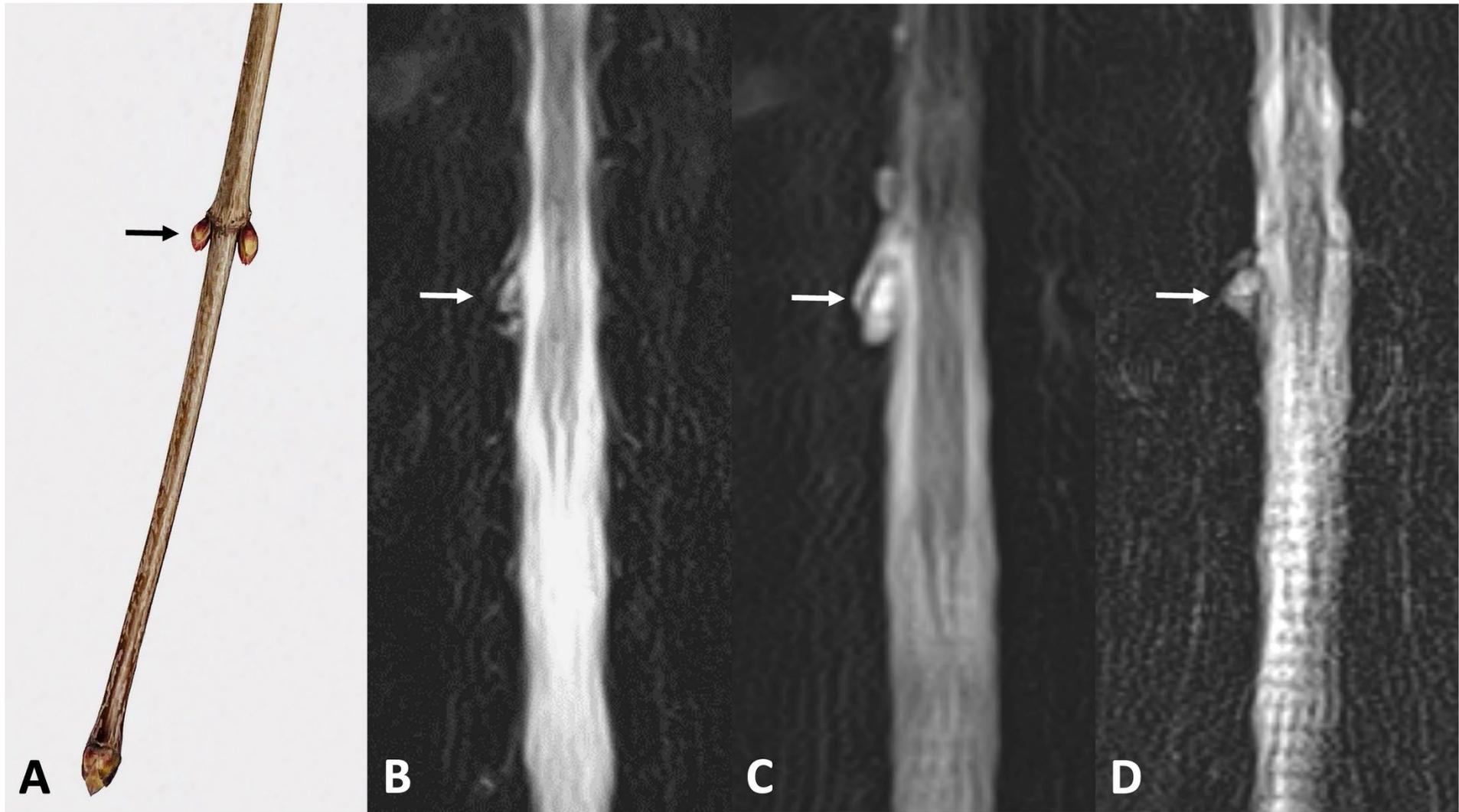
# Advanced Imaging of Type 2 Spinal CSF Leaks with Ultrahigh-Resolution Cone-Beam CT Myelography

AJNR

Niklas Lützen, Charlotte Zander, Jürgen Beck, Florian Volz, Katharina Wolf, Amir El Rahal, Horst Urbach

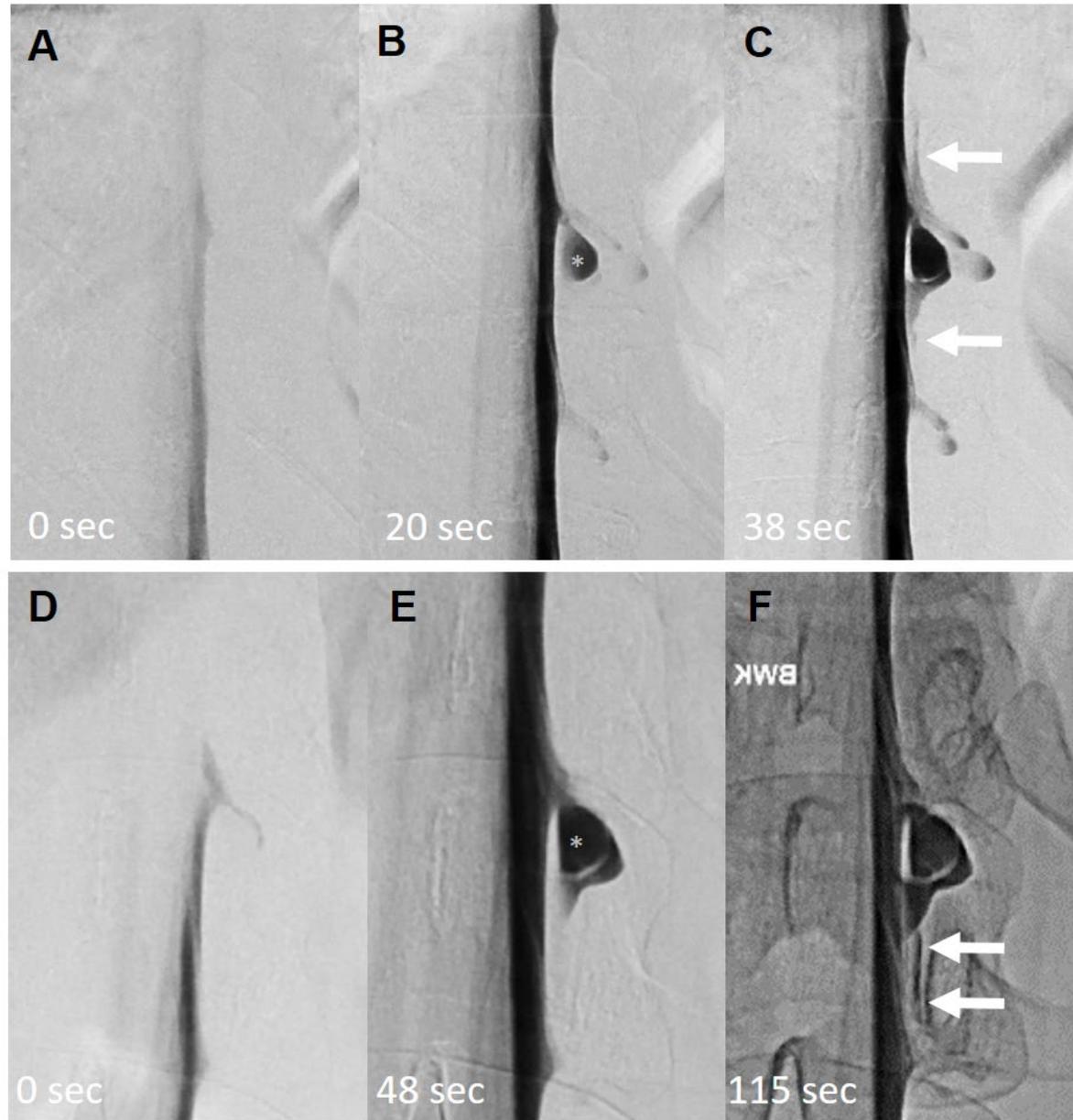


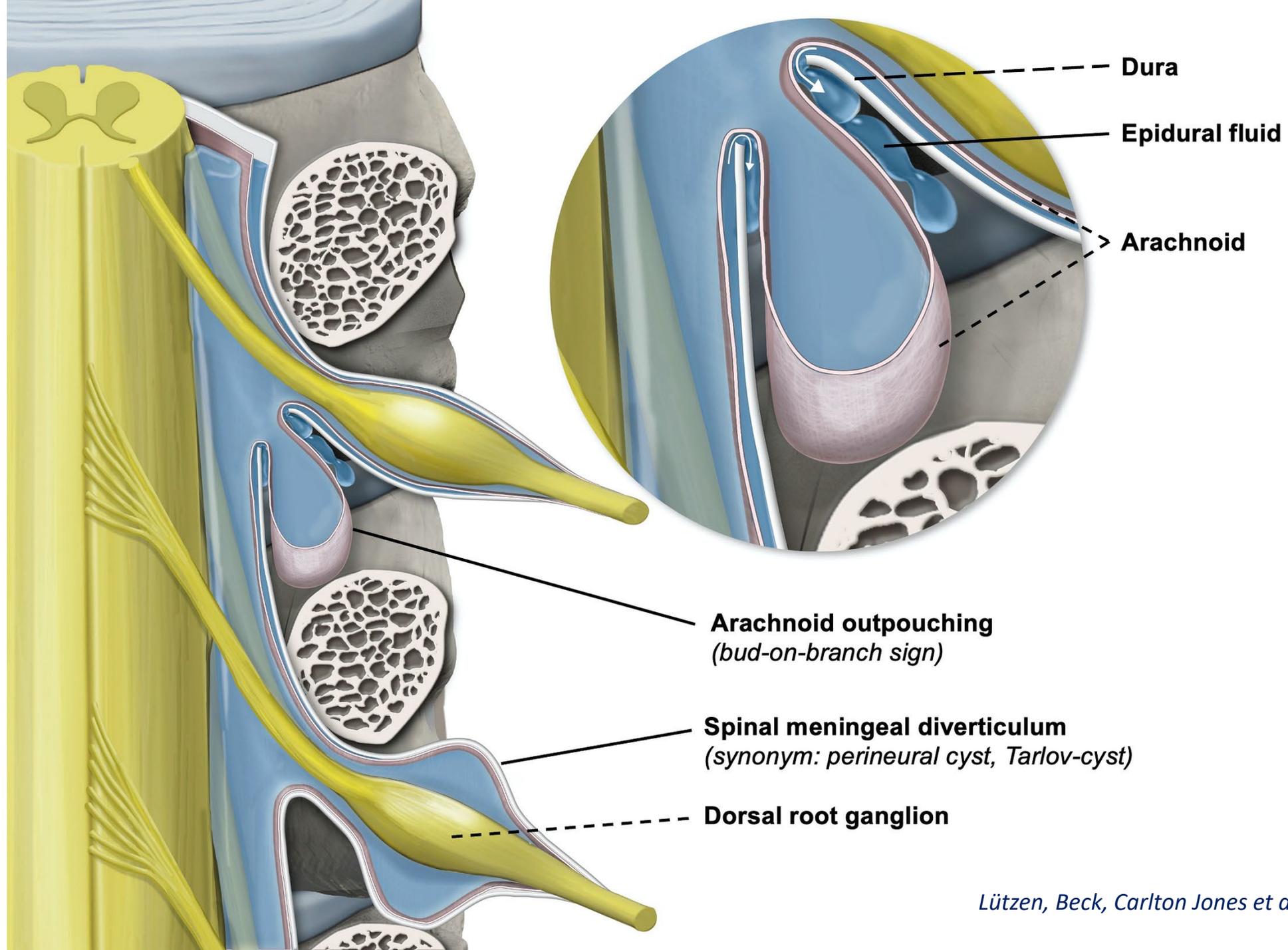




*Lützen, Beck, Carlton Jones et al. Radiology 2025*

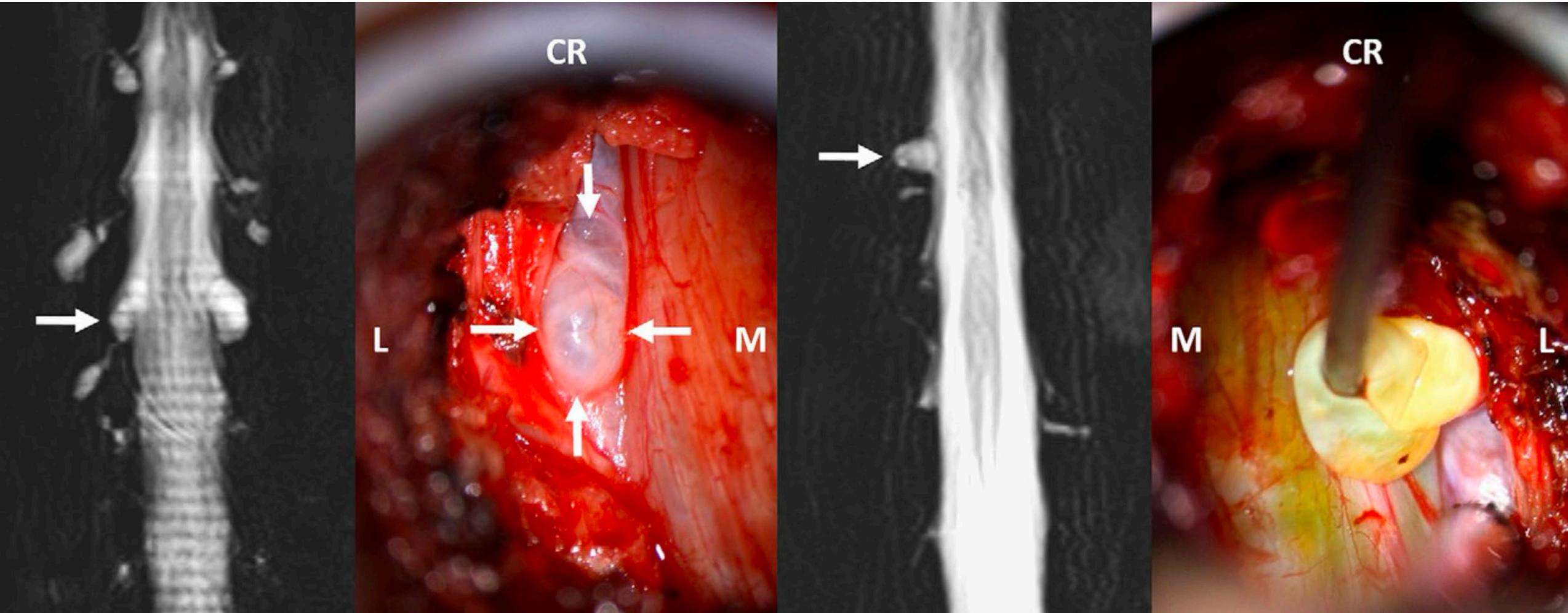
# Temporal Characteristics of Type 2 Lateral Spinal CSF Leaks on Digital Subtraction Myelography: High-, Medium- or Low-Flow Leaks?





# MRI and Surgical Findings Refine Concepts of Type 2 Cerebrospinal Fluid Leaks in Spontaneous Intracranial Hypotension

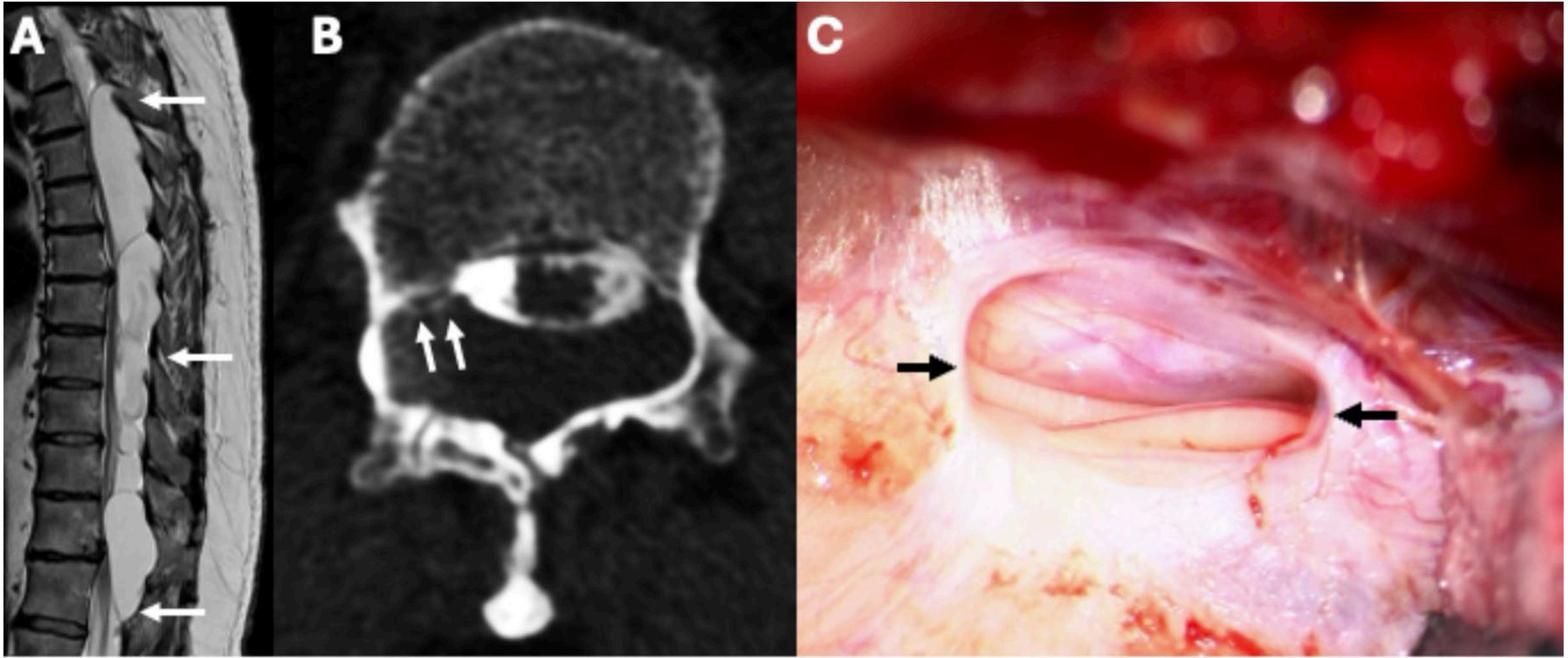
*Niklas Lützen, MD • Jürgen Beck, MD • Lalani Carlton Jones, MD • Christian Fung, MD • Theo Demerath, MD • Alexander Rau, MD • Charlotte Zander, MD • Katharina Wolf, MD • Florian Volz, MD • Amir El Rahal, MD • Horst Urbach, MD*



# Decubitus Myelography for Spinal Extradural Arachnoid Cyst— Better Classified as a Lateral Dural CSF Leak?

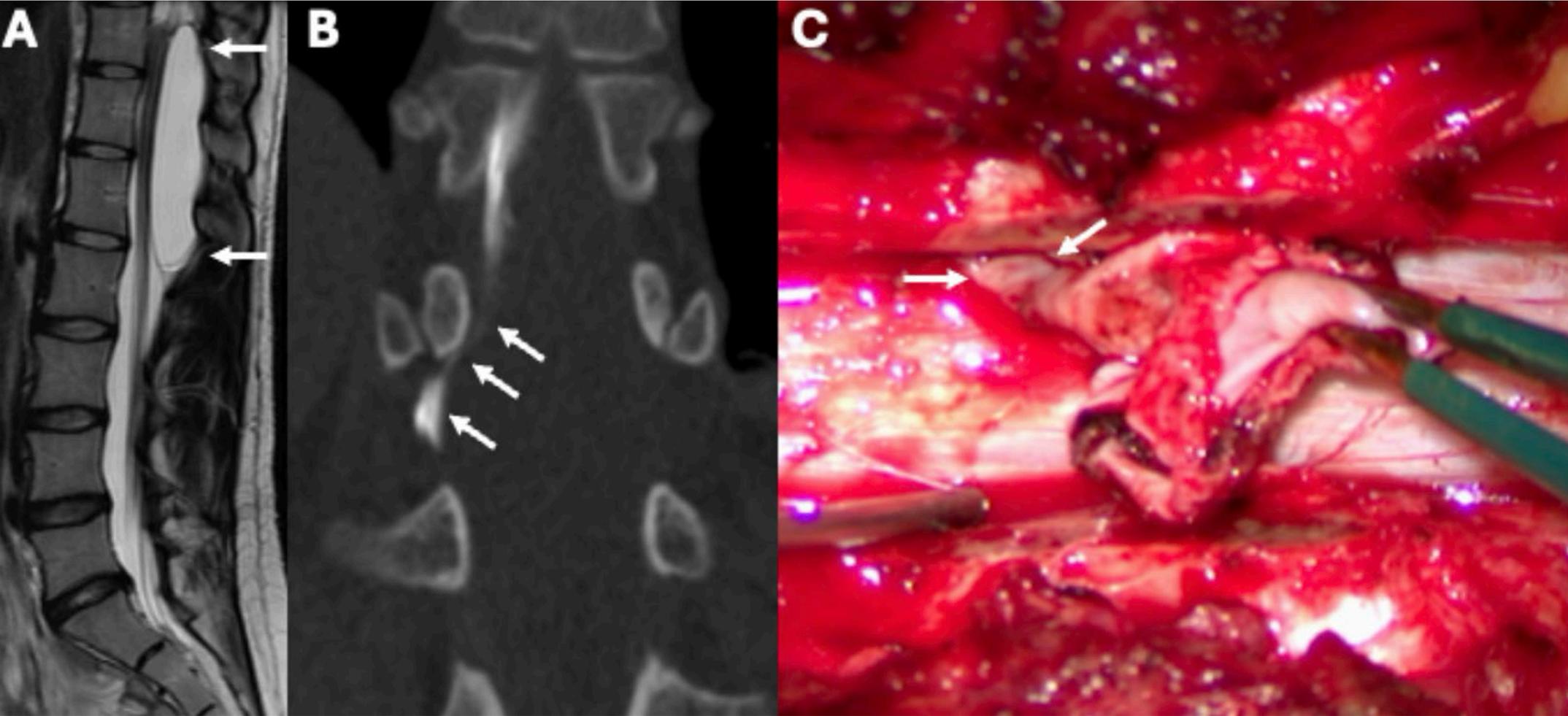
**AJNR**

Mark D. Mamlouk, Anthony R. Zamaray, Niklas Lützen, Jürgen Beck, Adriana Gutierrez, and Mark F. Sedrak

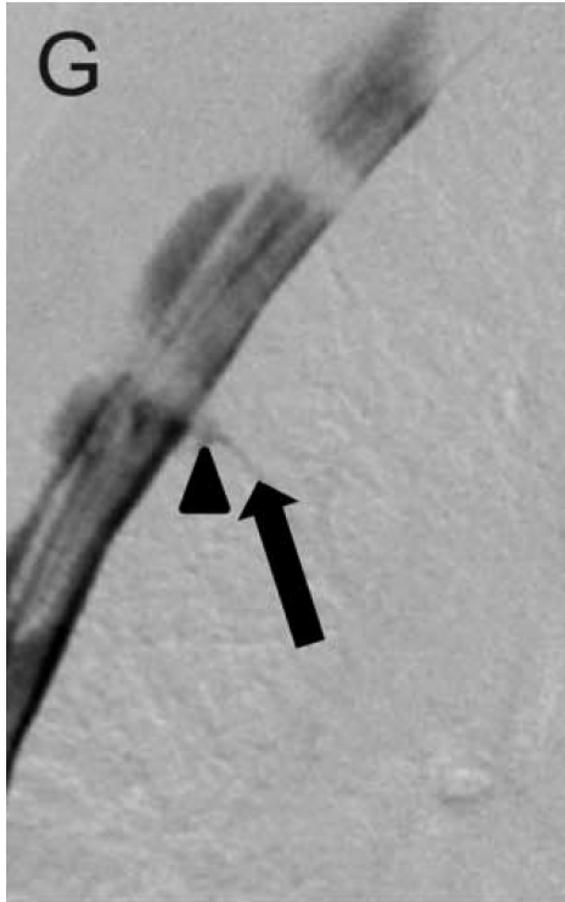


# Decubitus Myelography for Spinal Extradural Arachnoid Cyst— Better Classified as a Lateral Dural CSF Leak?

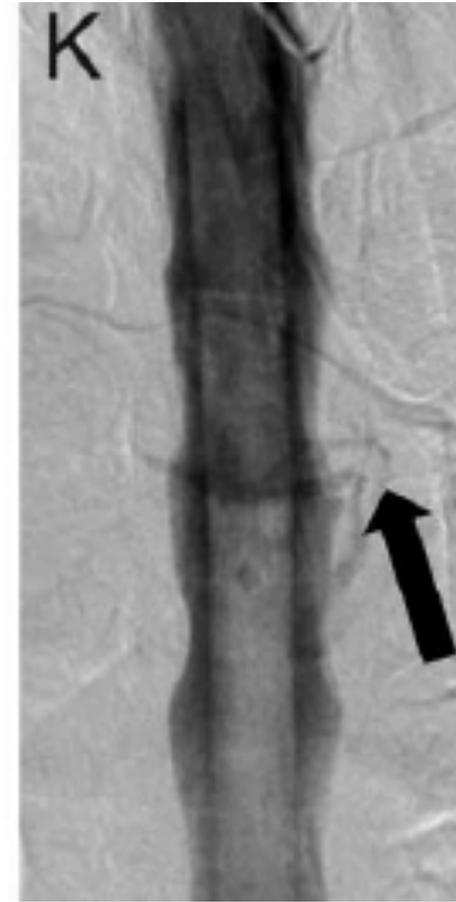
Mark D. Mamlouk, Anthony R. Zamary, Niklas Lützen, Jürgen Beck, Adriana Gutierrez, and Mark F. Sedrak



# Pathophysiology – direct CSF-venous fistula

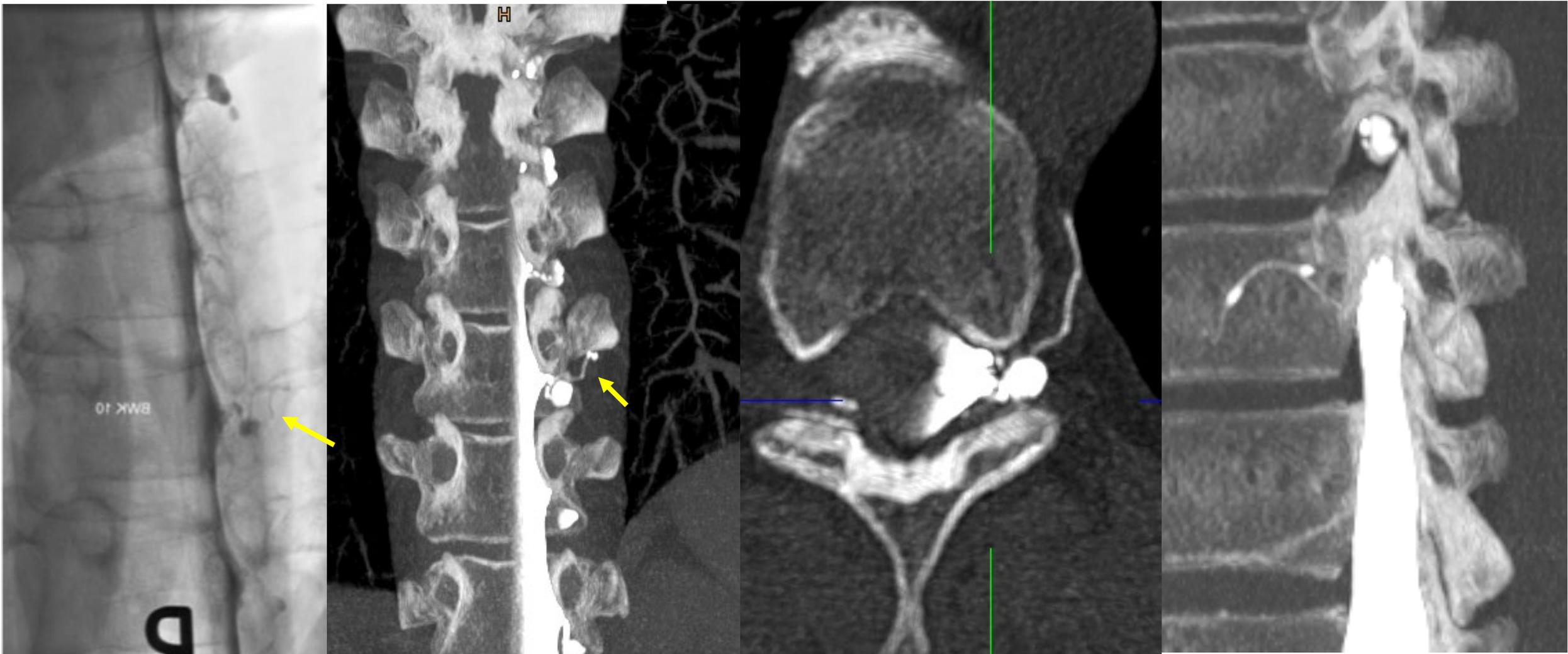


Neurology 83 July 29, 2014



Schievink et al.

# CSF venous fistula Th10/11 left



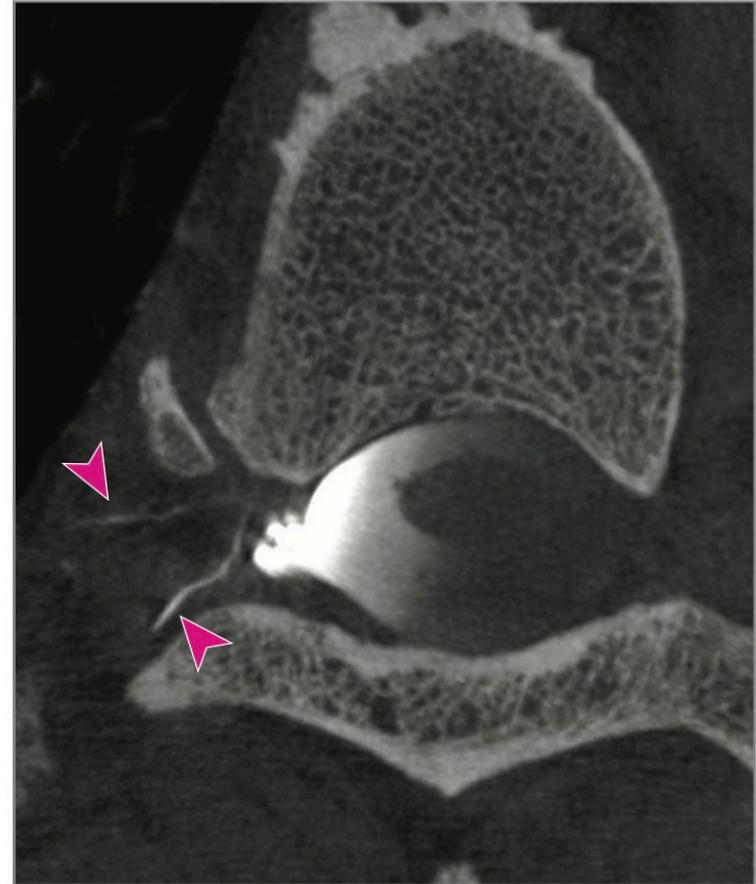
Left decubitus (digital subtraction) myelography and CT myelography

Images in Neurology

# Cerebrospinal Fluid Venous Fistula Imaging with Ultrahigh-Resolution Cone-Beam Computed Tomography

Niklas Lützen, MD; Jürgen Beck, MD; Horst Urbach, MD

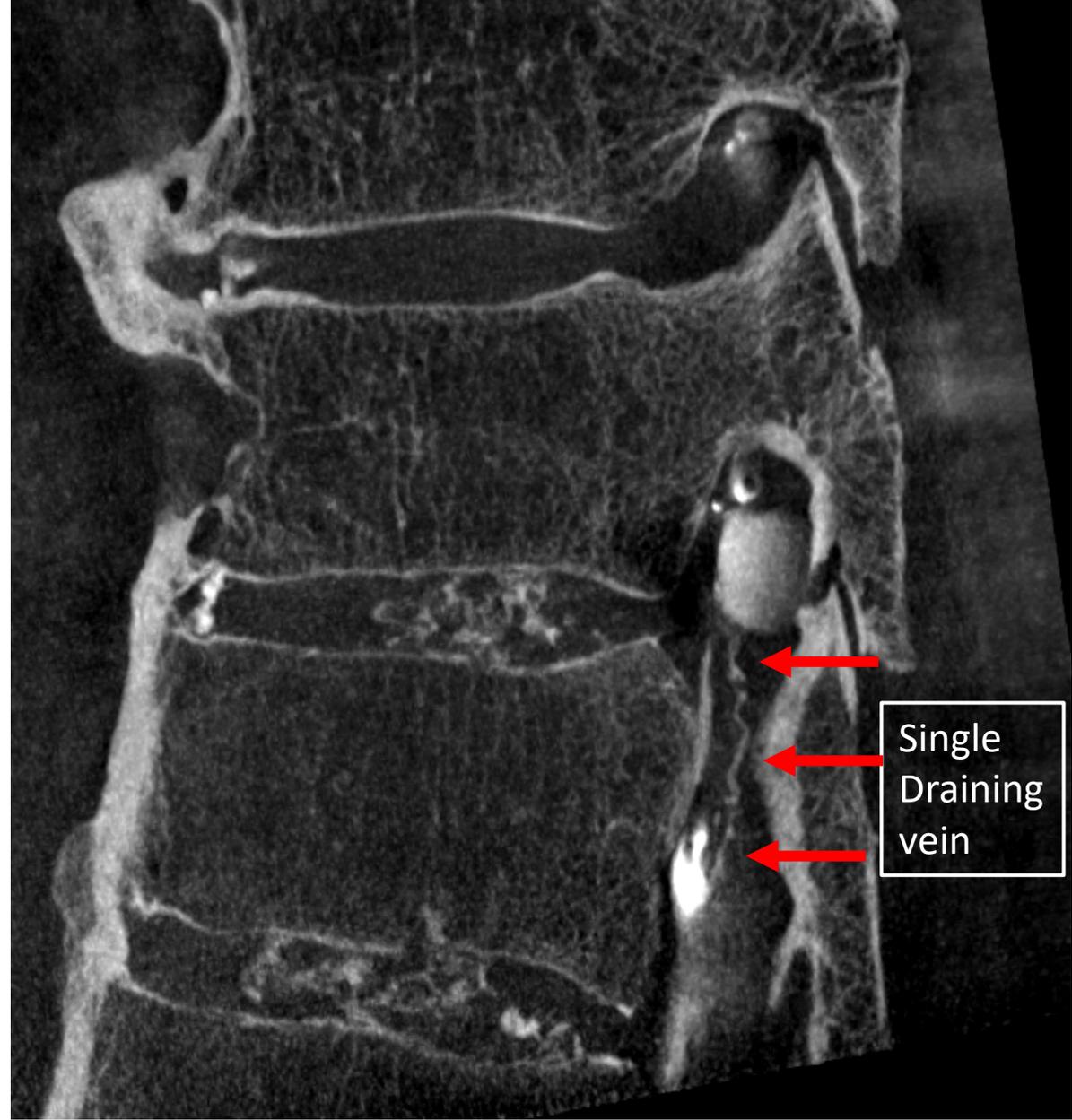
**JAMA Neurology** Published online June 12, 2023





no specific finding

CTM



Single  
Draining  
vein

Ultra-high resolution CB-CT

R A H

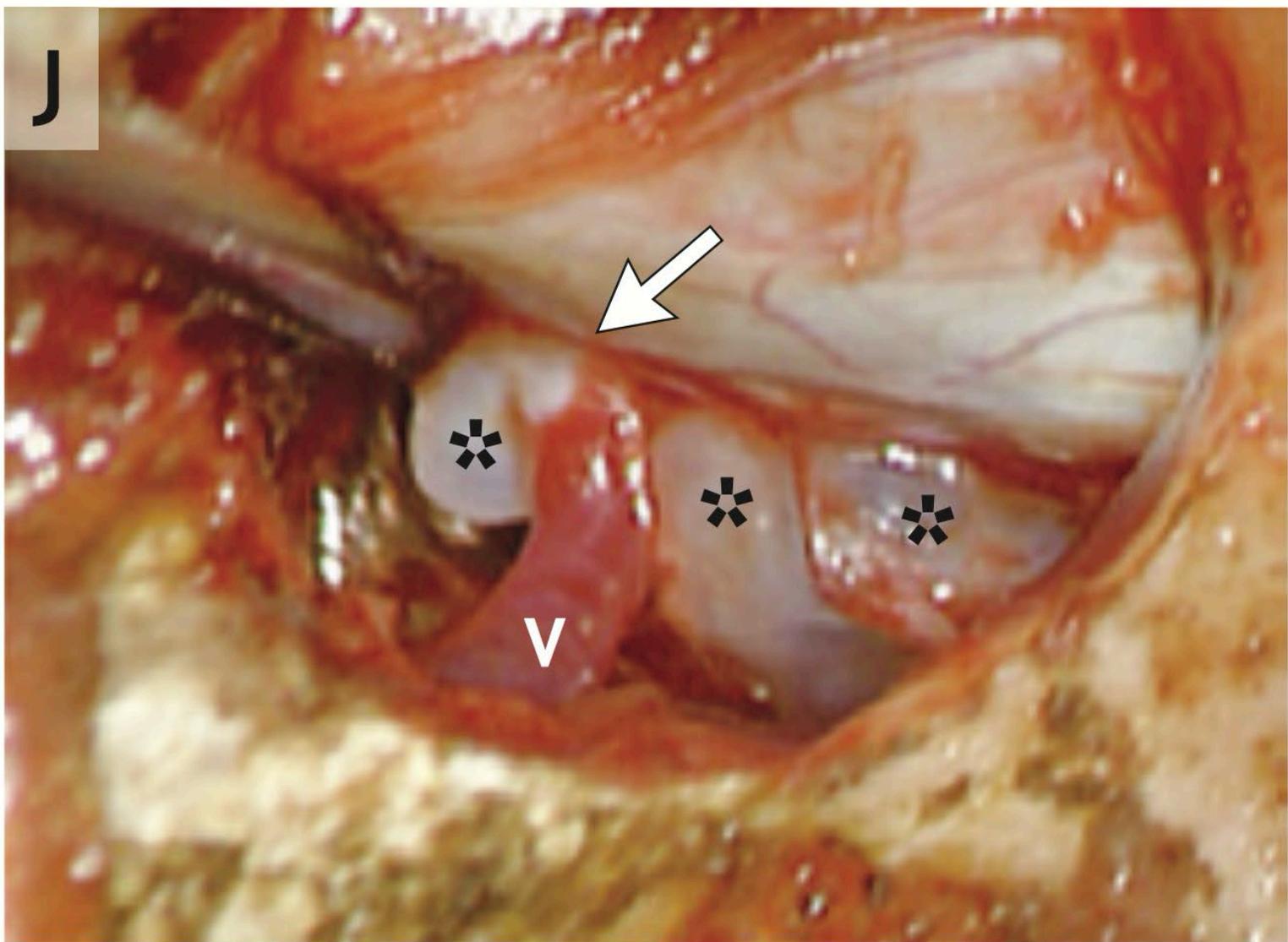
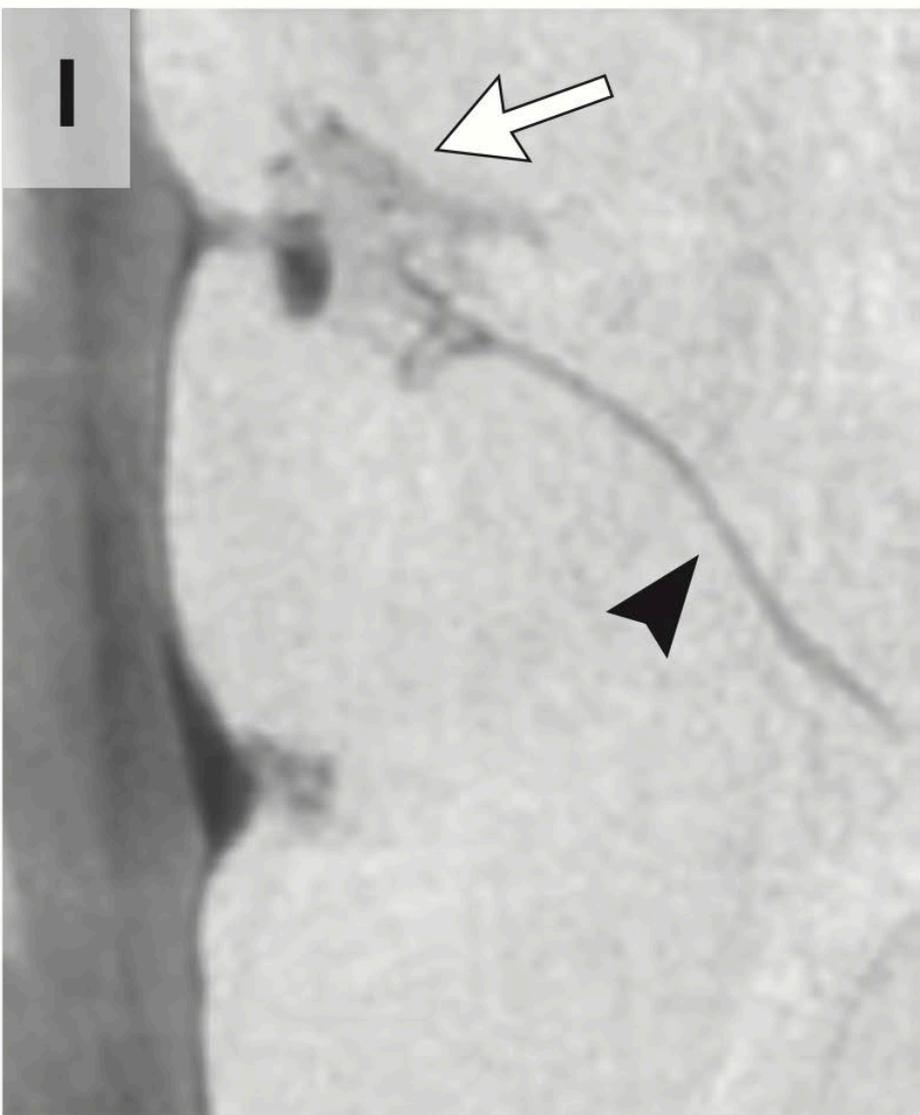
8 mm

Schichtdicke: 2.72mm

Modus: MIP

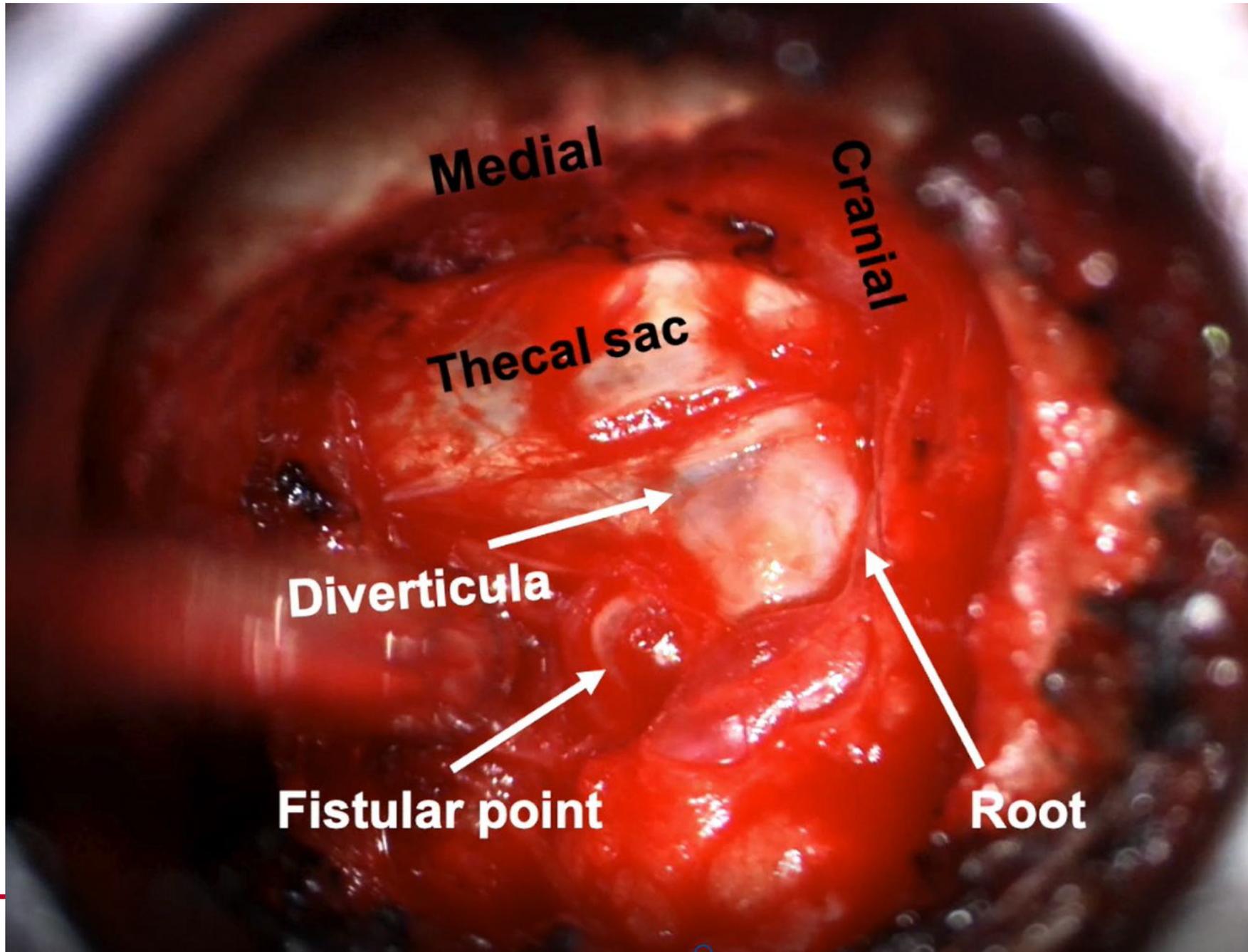
© Lützen, Urbach – Neuroradiology Neurocenter, University of Freiburg

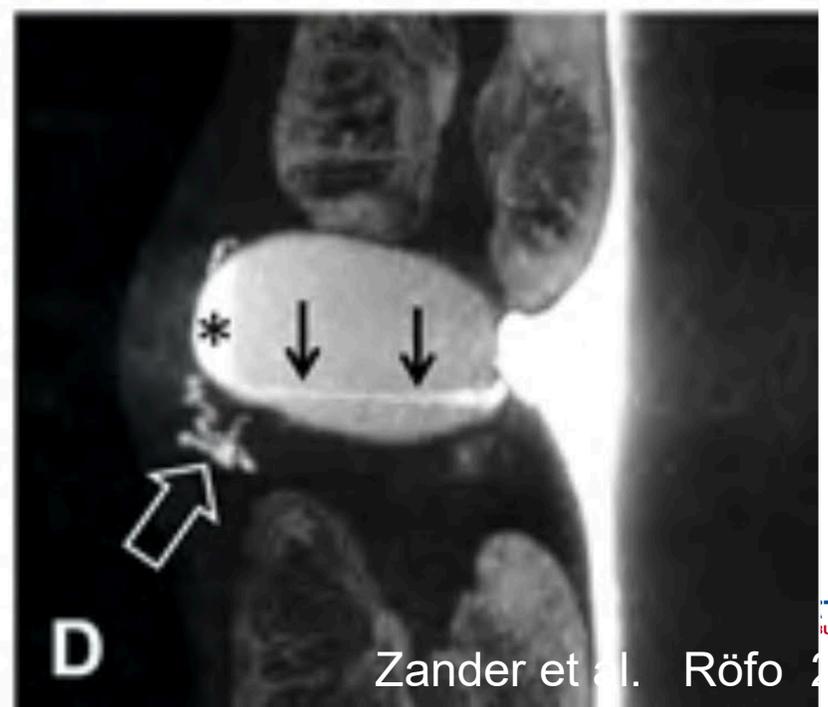
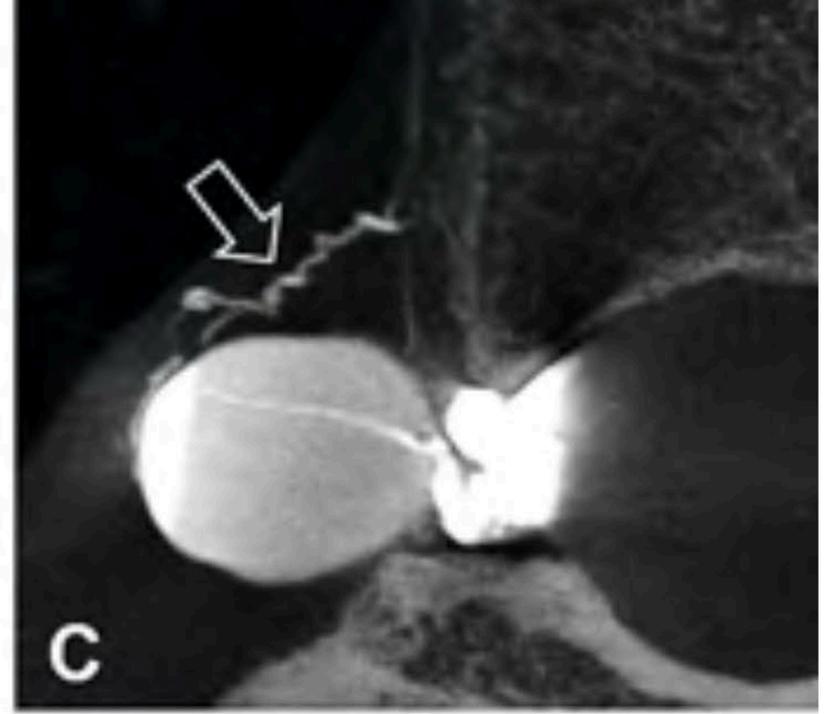


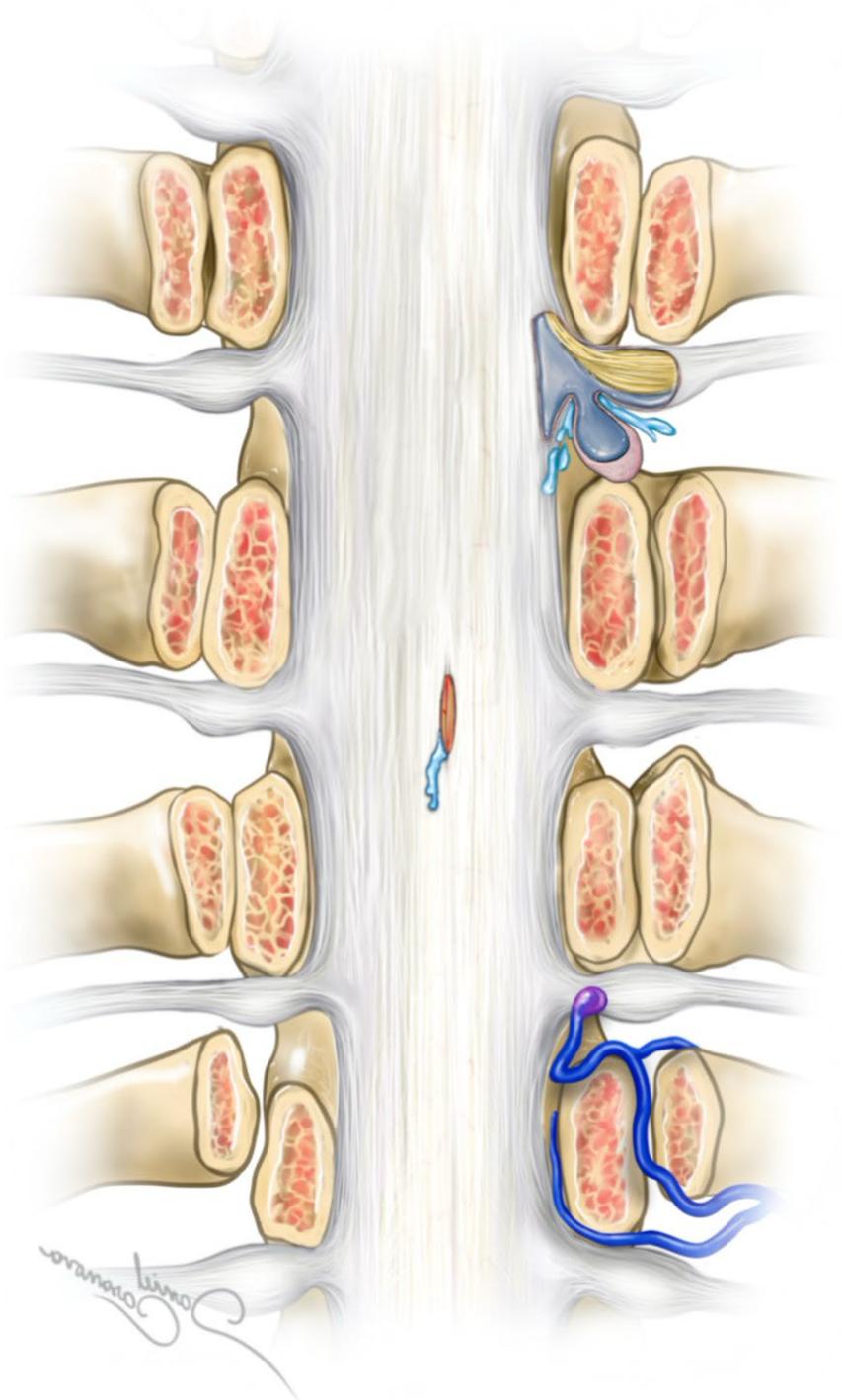


## CSF–Venous Fistula

# CSF-venous fistula







← Type 2

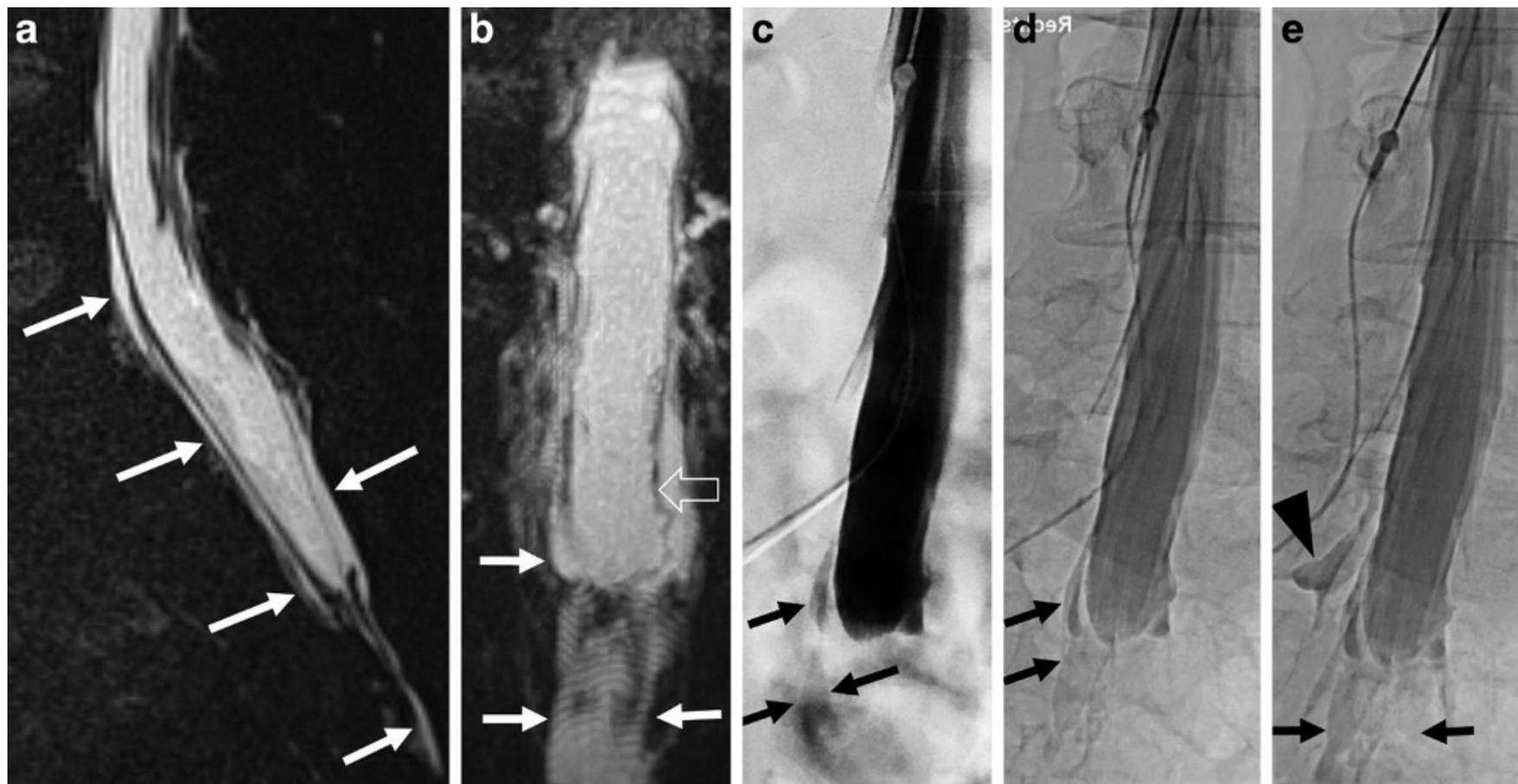
← Type 1

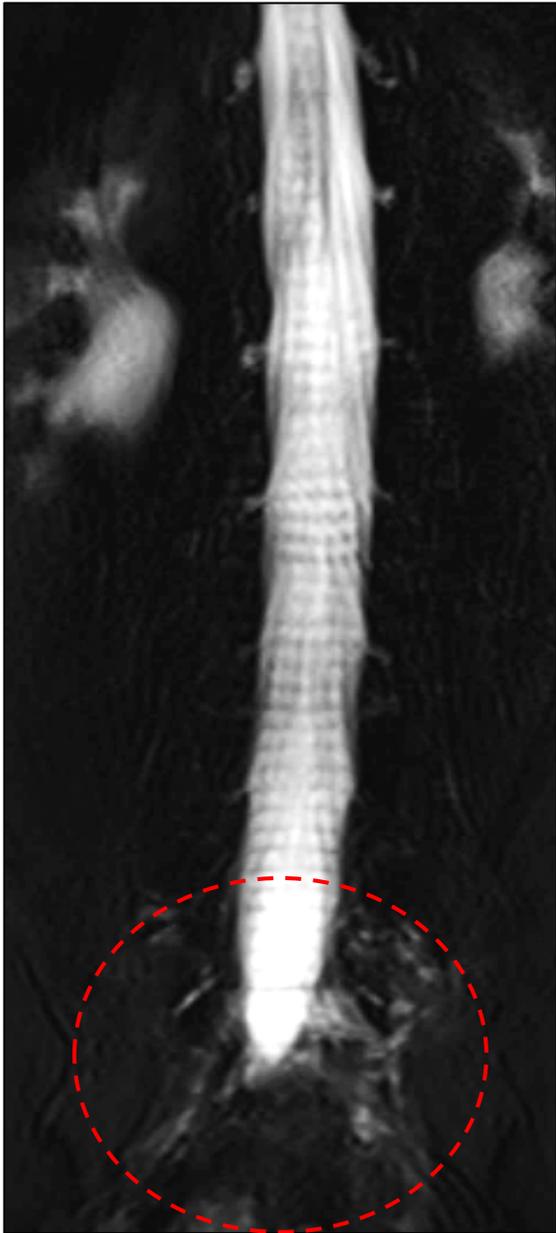
← Type 3

*Overstijns et al. under review*

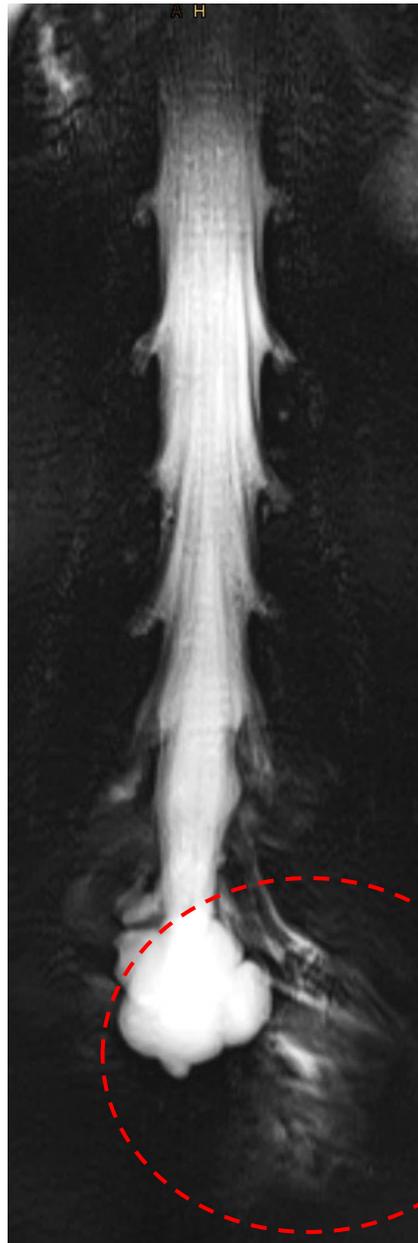
# Sacral Dural Tears as a Cause of Spontaneous Intracranial Hypotension

Niklas Lützen<sup>1</sup>  · Enrique Barvulsky Aleman<sup>1</sup> · Amir El Rahal<sup>2</sup> · Florian Volz<sup>2</sup> · Christian Fung<sup>2</sup> · Jürgen Beck<sup>2</sup> · Horst Urbach<sup>1</sup>

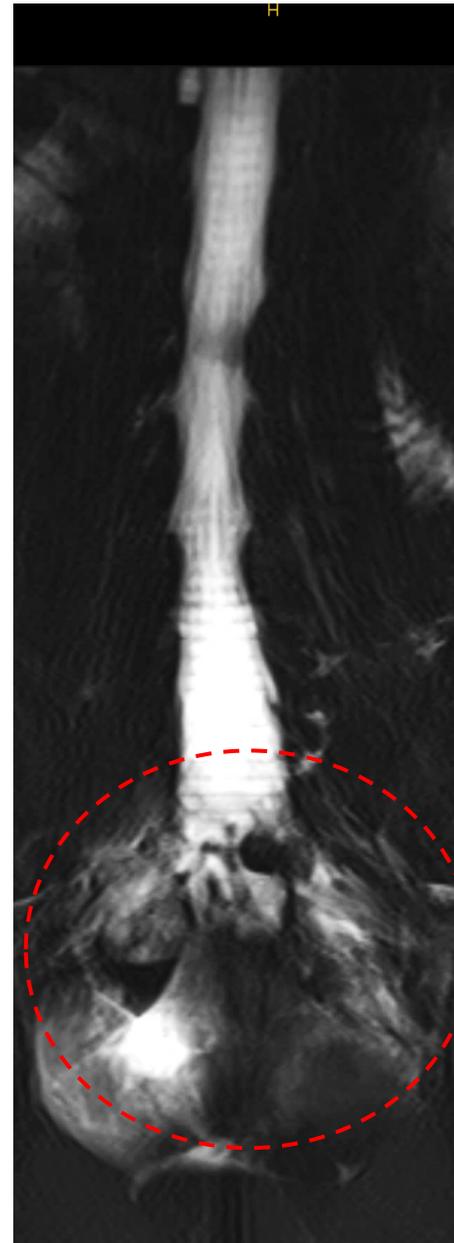




Acute sacral SLECs, bilateral

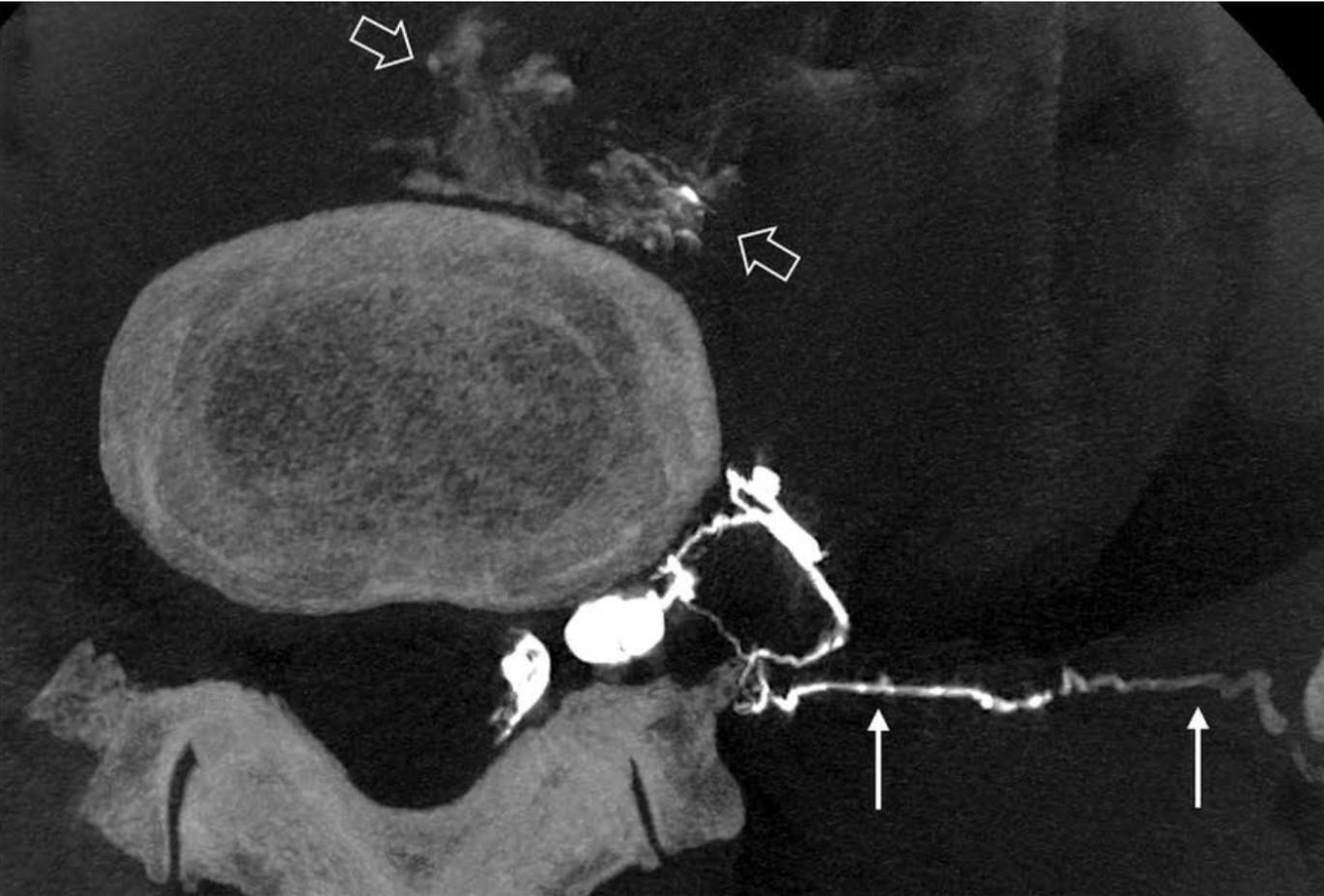


Acute sacral SLECs, unilateral



Acute sacral SLECs, bilateral

## Primary CSF-lymphatic fistula

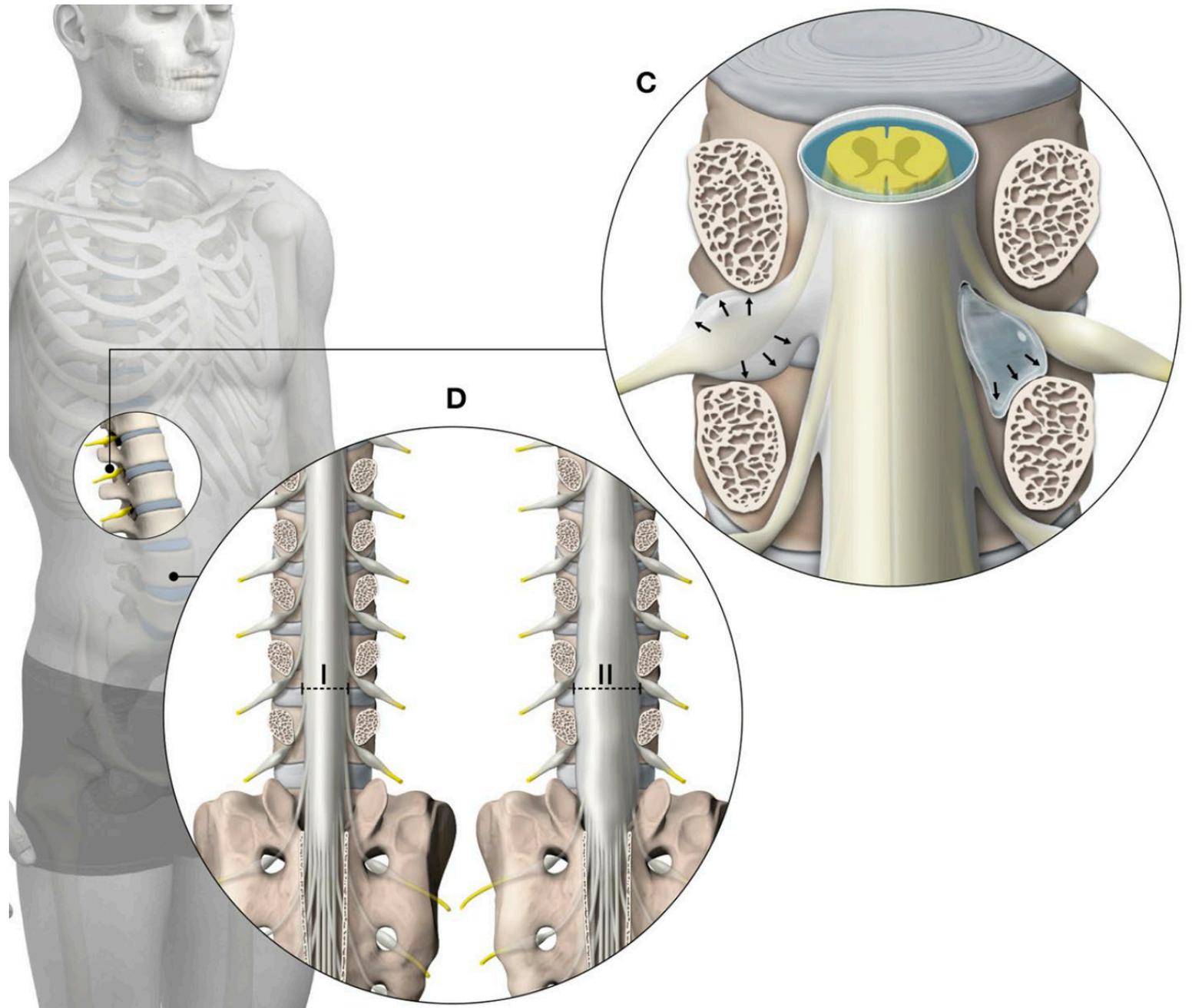


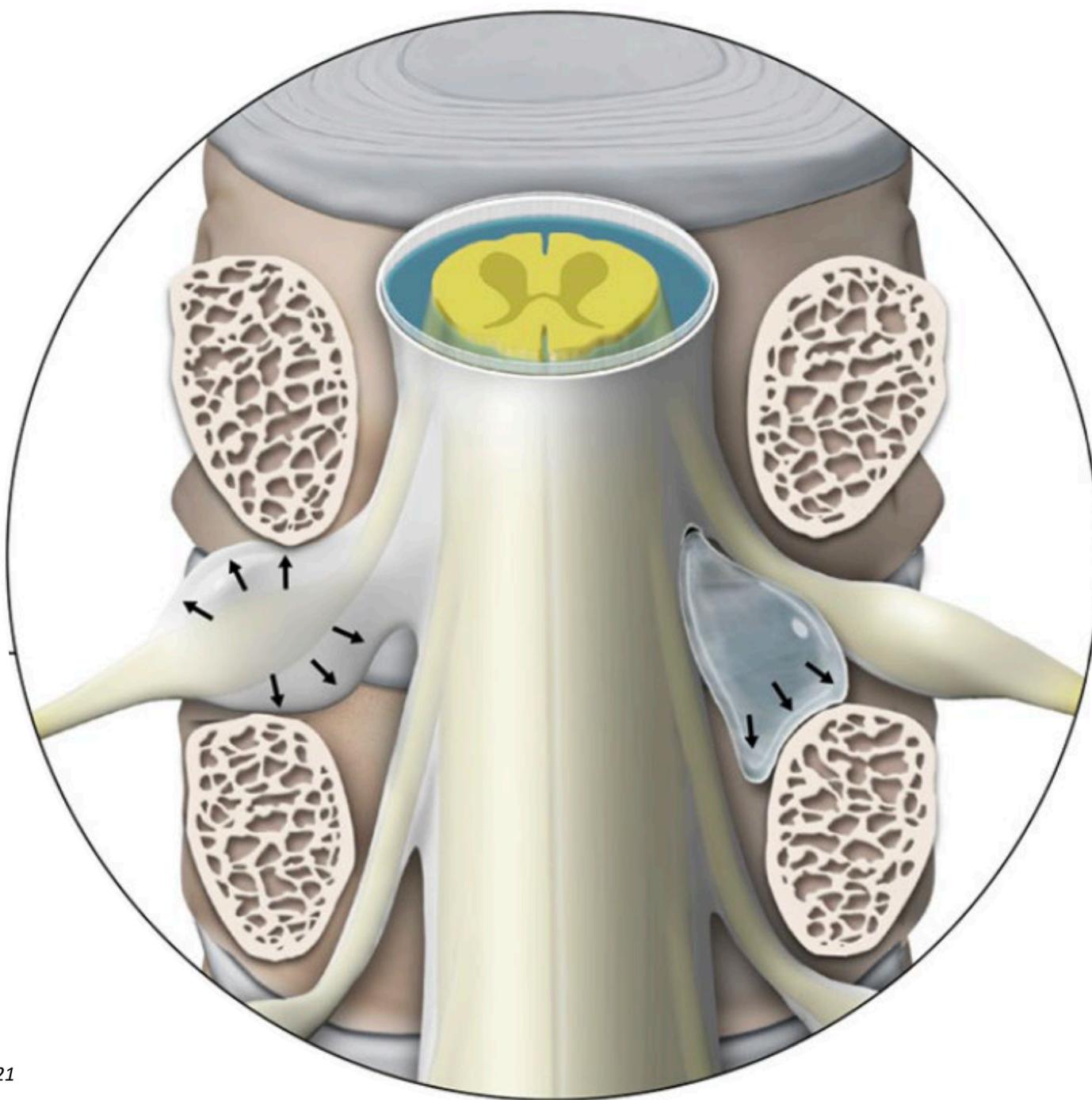
**Primary CSF-lymphatic fistula: a previously unknown cause of spontaneous intracranial hypotension**

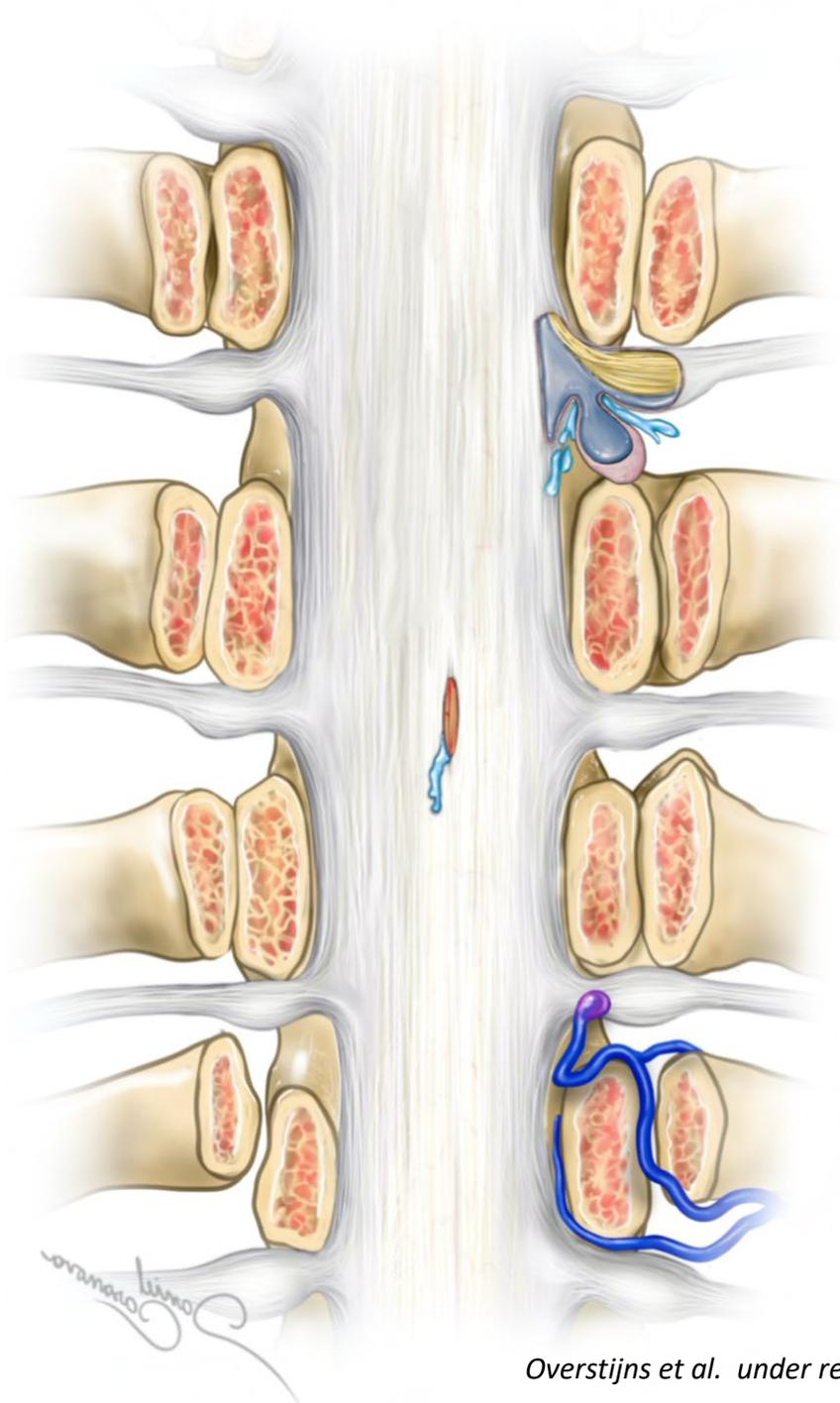
Niklas Lützen<sup>1</sup>  · Katharina Wolf<sup>2</sup> · Amir El Rahal<sup>2</sup> · Florian Volz<sup>2</sup> · Theo Demerath<sup>1</sup> · Charlotte Zander<sup>1</sup> · Claus Christian Pieper<sup>3</sup> · Marius Schwabenland<sup>4</sup> · Horst Urbach<sup>1</sup> · Jürgen Beck<sup>2</sup>

# Spontaneous Intracranial Hypotension Without CSF Leakage – Concept of a Pathological Cranial to Spinal Fluid Shift

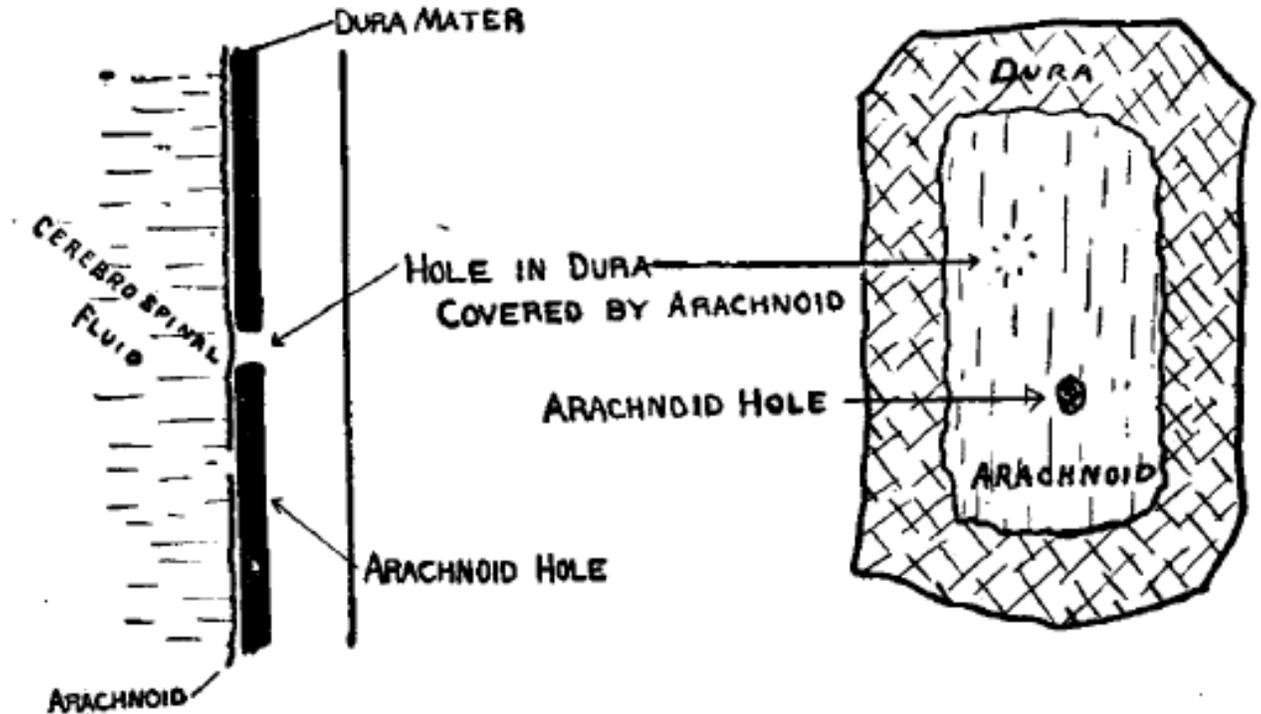
Johannes Goldberg<sup>1†</sup>, Levin Häni<sup>1†</sup>, Christopher Marvin Jesse<sup>1</sup>, Irena Zubak<sup>1</sup>, Eike I. Piechowiak<sup>2</sup>, Jan Gralla<sup>2</sup>, Tomas Dobrocky<sup>2</sup>, Jürgen Beck<sup>3</sup> and Andreas Raabe<sup>1\*</sup>







RUSSELL G. MACROBERT, M.B. (TOR.)  
 Associate Physician, Neurological Institute  
 NEW YORK



JOUR. A. M. A.  
 MAY 11, 1918

# 4th Freiburg & Bern CSF Center Visitorship

November, 5<sup>th</sup> – 7<sup>th</sup> 2025

Freiburg CSF Center  
Prof. Dr. Jürgen Beck



CSF

CSF CENTER





EANS CEREBROSPINAL FLUID  
SECTION

## International Collaborations

Inselspital Bern, Switzerland

Lindenhofspital Bern, Switzerland

UZH Zuerich, Switzerland

AKH, Vienna, Austria

University College London, UK

King's College, UK

Danish Headache Center, Denmark

Cedars Sinai, CA, USA

Stanford, CA, USA

Nagoya University, Japan

# CSF-Center Freiburg



### Neurosurgery & Neurology

J. Beck, K. Wolf, F. Volz, A. El Rahal, V. Vieira da Silva  
L. Krismer, M. Overstijns, M. Shah

### Neuroradiology

H. Urbach, N. Lützen,  
C. Zander, T. Demerath



**Nuclear Medicine**  
P.T. Meyer & Team

**Anesthesiology**  
H. Bürkle & Team

**Neuroophthalmology**  
W. Lagrèze & Team

**Neuromedical AI Lab**  
T. Ball & Team

**Medical Physics**  
M. Reisert & Team

Freiburg CSF Center  
Prof. Dr. Jürgen Beck



CSF CENTER

FREIBURG



MINISTERIUM FÜR WISSENSCHAFT, FORSCHUNG UND KUNST  
Baden-Württemberg



@JrgenBeck  
@Niklas\_Luetzen  
@KathaDCwolf  
@ZanderCharlotte

# Thank you

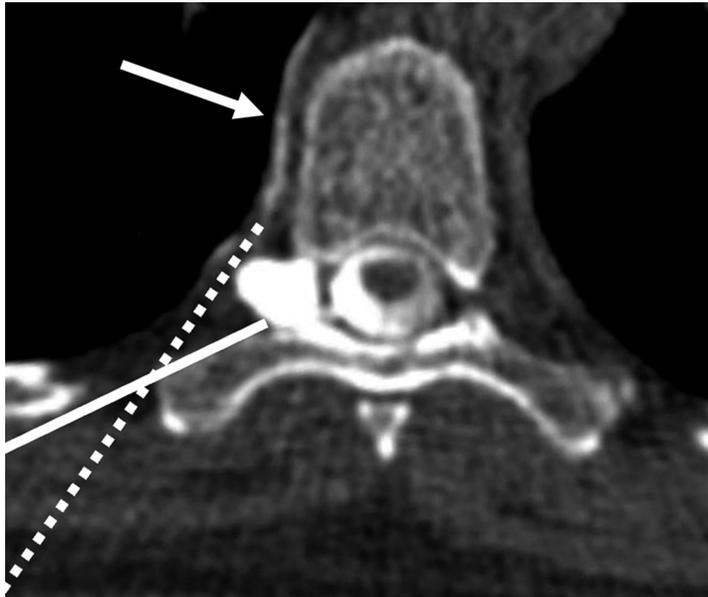


*Freiburg im Breisgau, Germany*

*[j.beck@uniklinik-freiburg.de](mailto:j.beck@uniklinik-freiburg.de)*

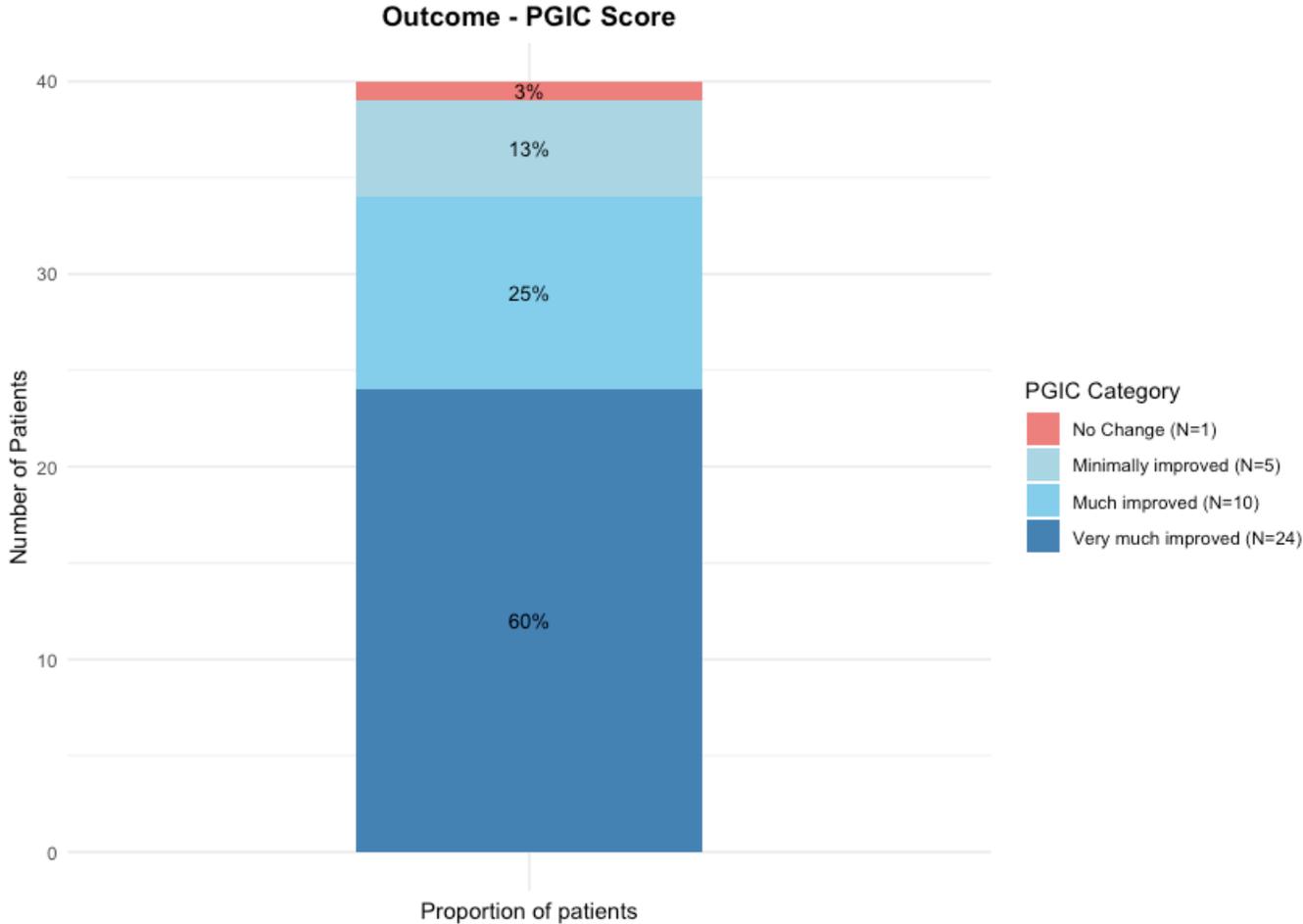
# Factors Predictive of Treatment Success in CT-Guided Fibrin Occlusion of CSF-Venous Fistulas: A Multicenter Retrospective Cross-Sectional Study

 Andrew L. Callen,  Lalani Carlton Jones,  Vincent M. Timpone,  Jack Pattee,  Daniel J. Scoffings,  David Butteriss,  Thien Huynh,  Peter Y. Shen, and  Mark D. Mamlouk



Clinical improvement	
Complete	71 (59.7%)
None	7 (5.9%)
Partial	41 (34.5%)

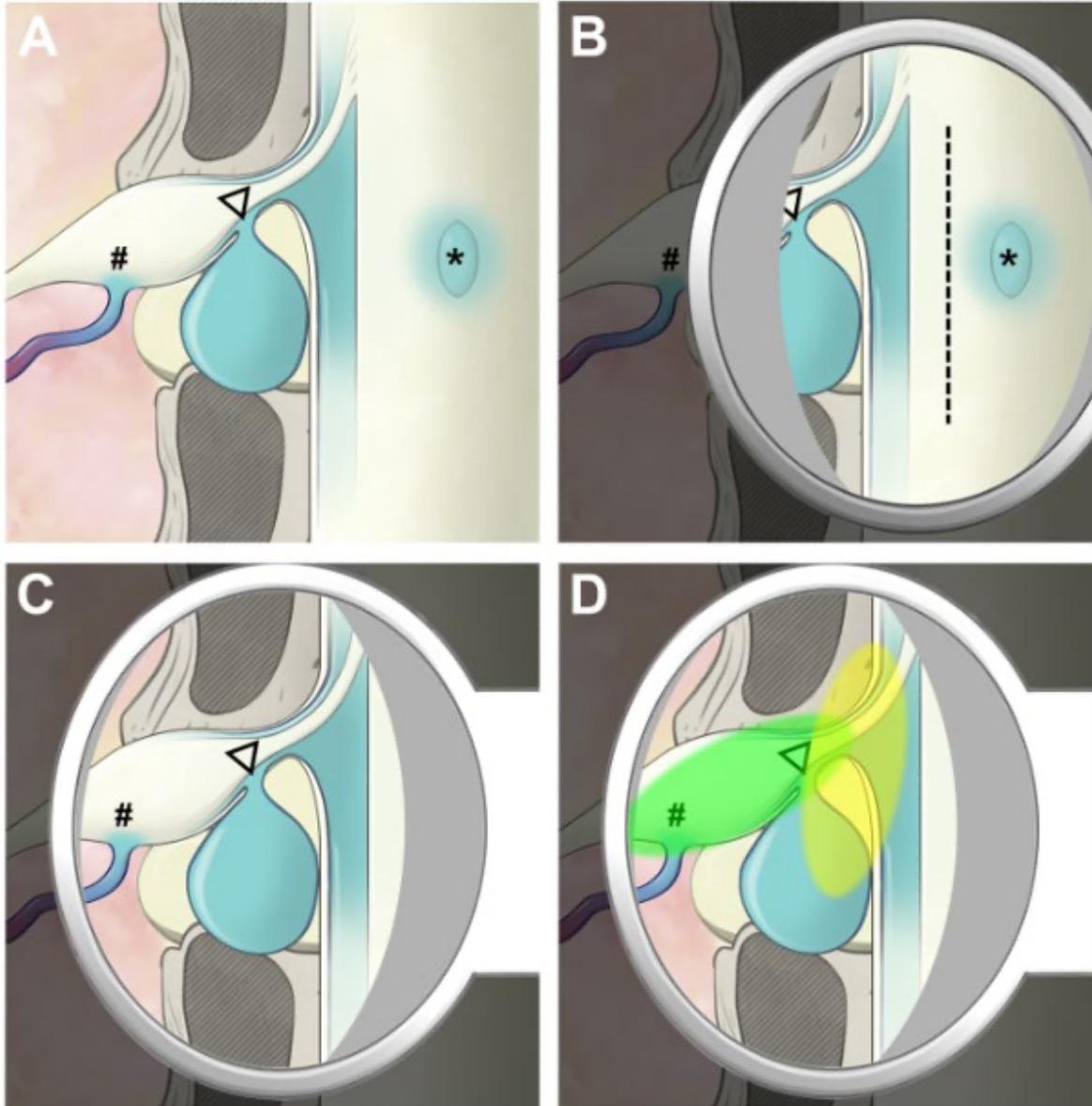
# Nerve root clipping - Patient Global Impression of Change (PGIC)



85% very much/much improved  
98% improved

*El Rahal Beck J, Volz et al. 2024*

# Surgical Treatment

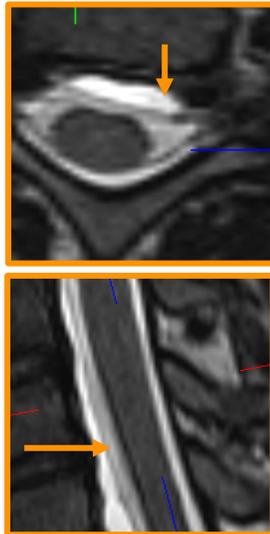


**One Approach fits all**

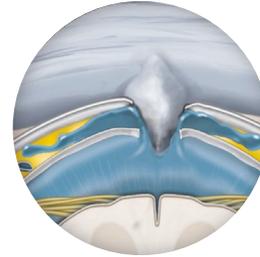


# Spontaneous Intracranial Hypotension

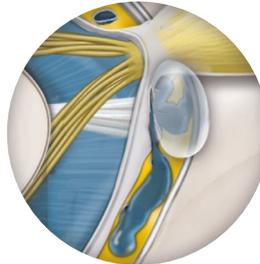
## CLEAR FINDINGS



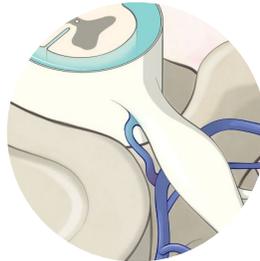
## KNOWN CAUSES



Typ 1 - ventral leak



Typ 2 – lateral leak

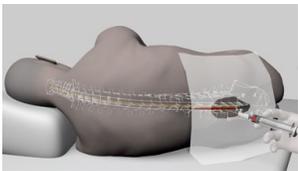
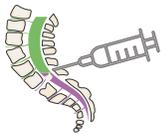


Typ 3 – CSF venous fistula

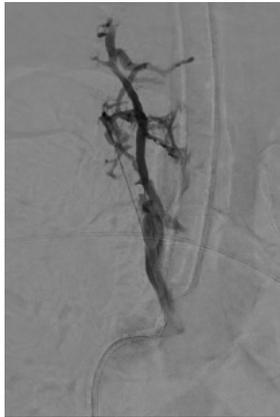
# Spontaneous Intracranial Hypotension

## EFFECTIVE TREATMENT

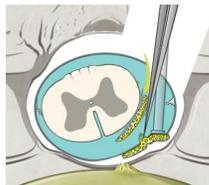
### (Blood) Patching



### Embolization



### Surgery



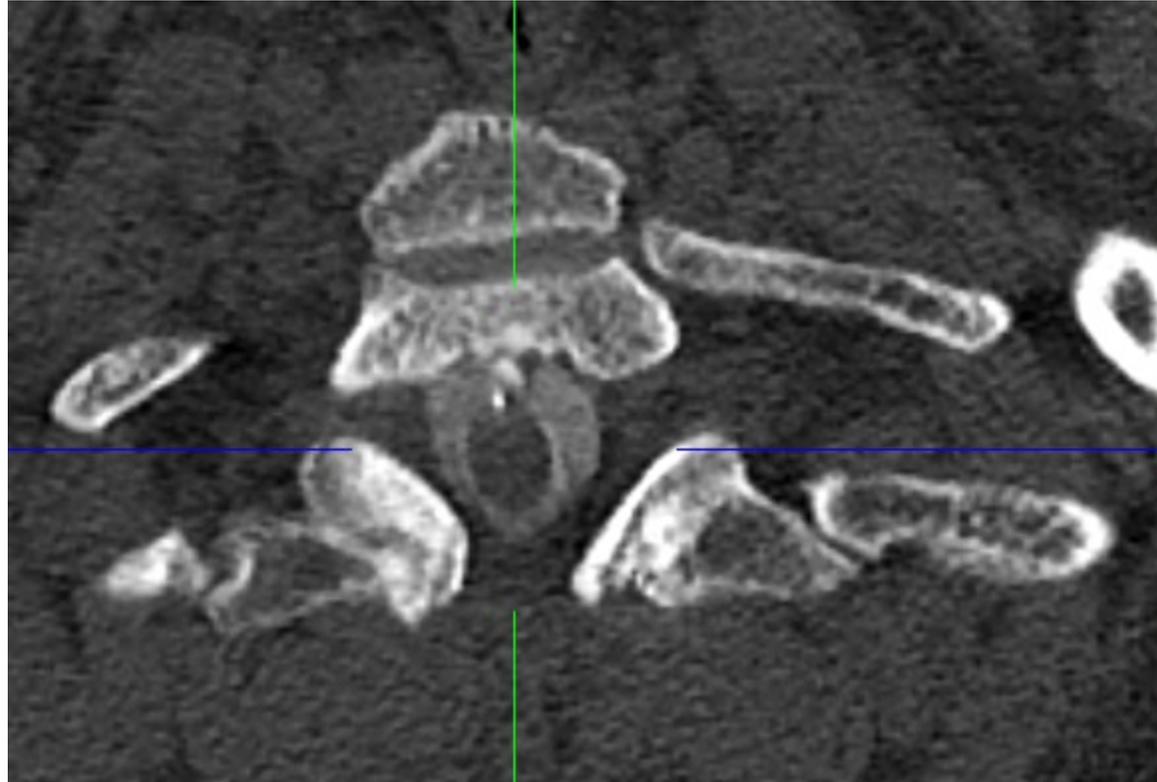
## CONSENSUS GUIDELINE

### General neurology

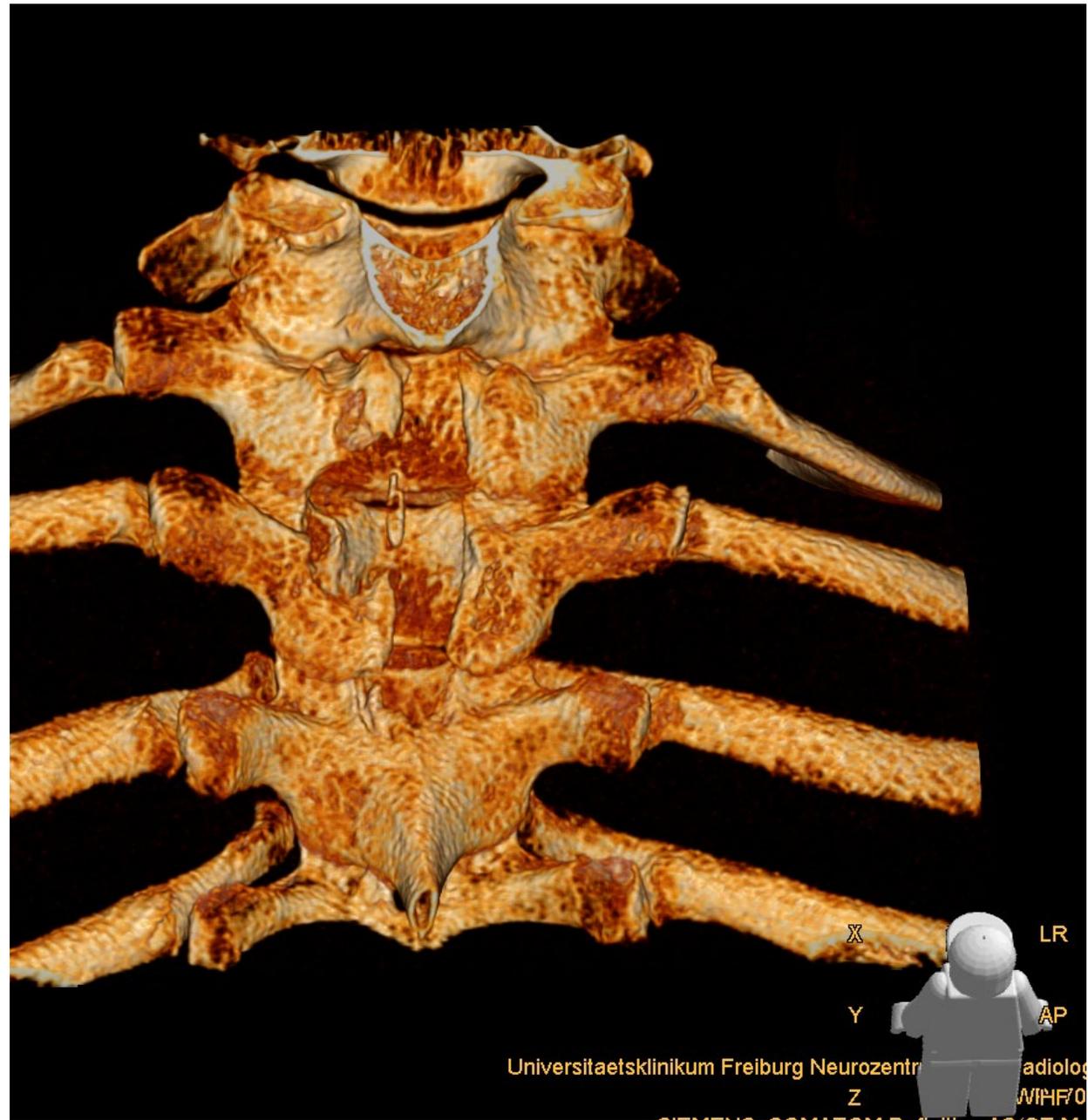
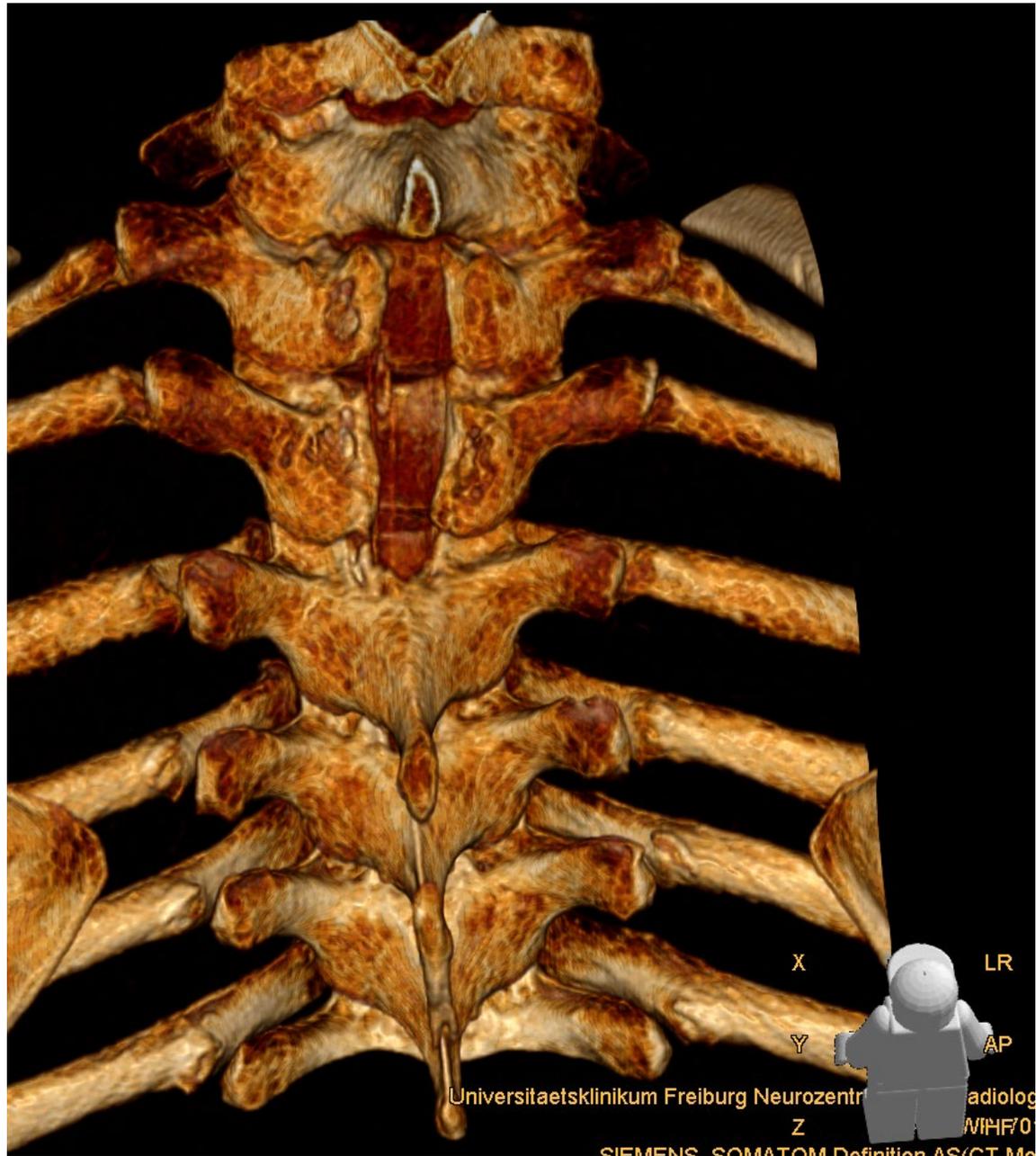
Original research

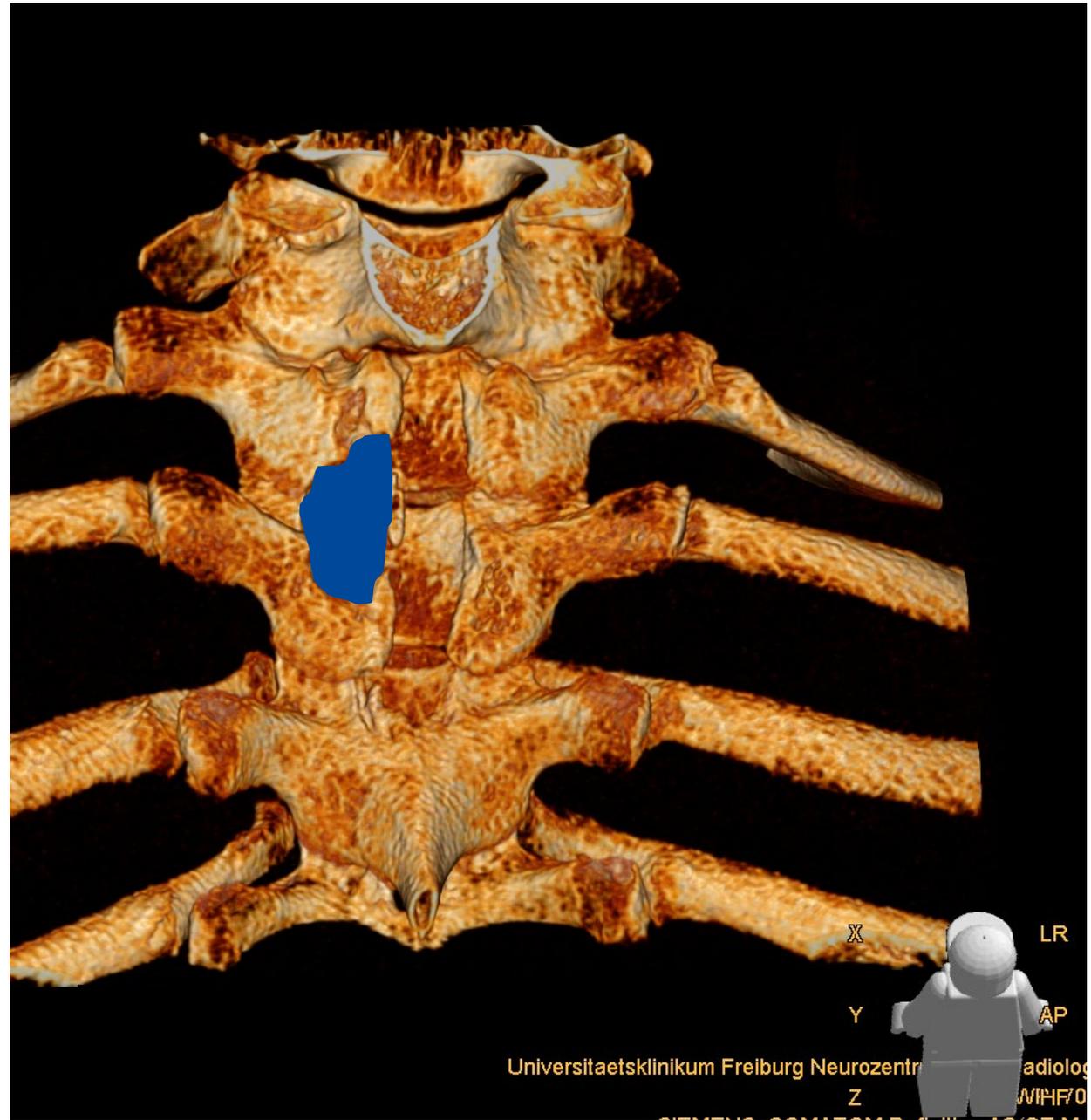
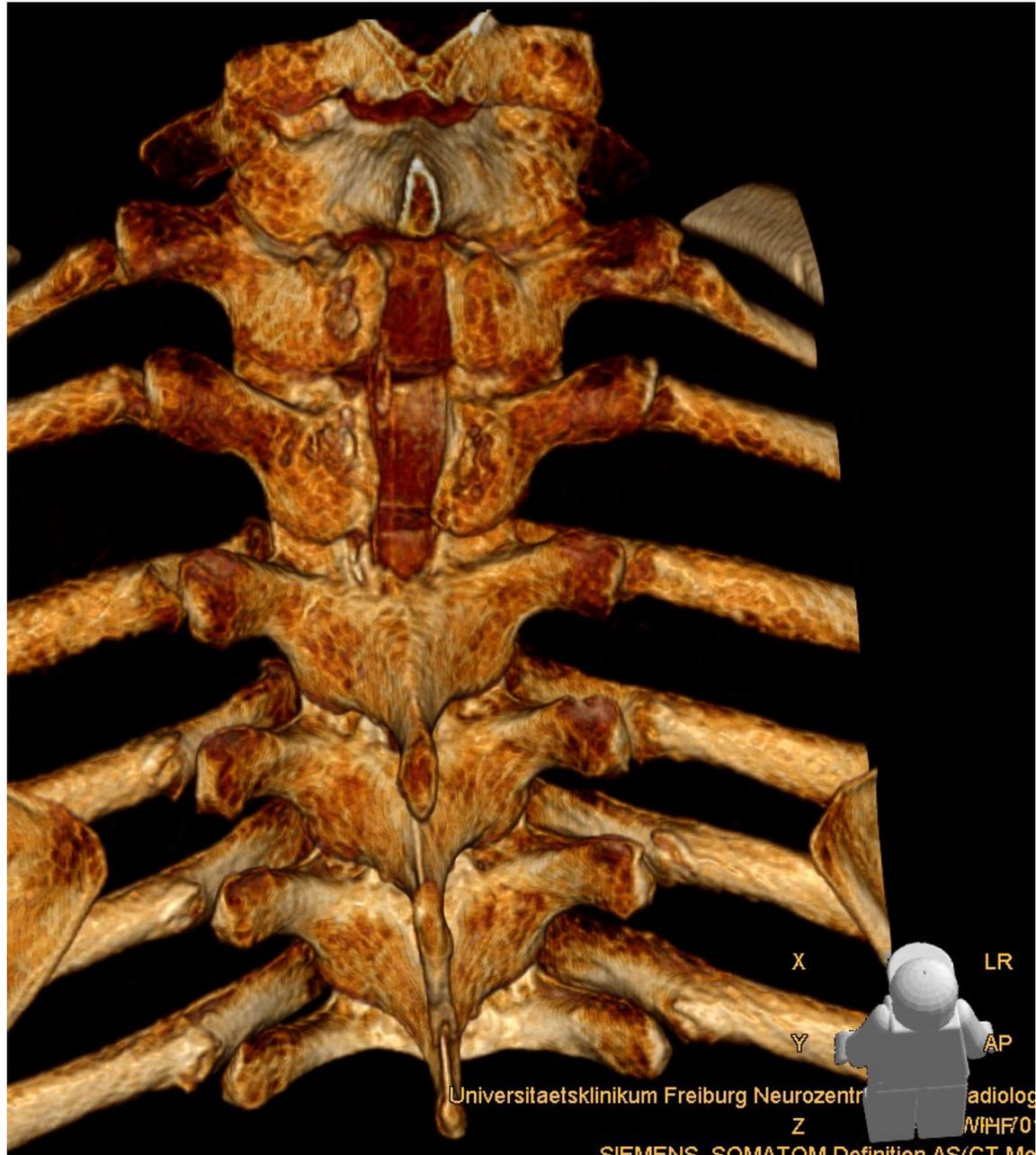
### Multidisciplinary consensus guideline for the diagnosis and management of spontaneous intracranial hypotension

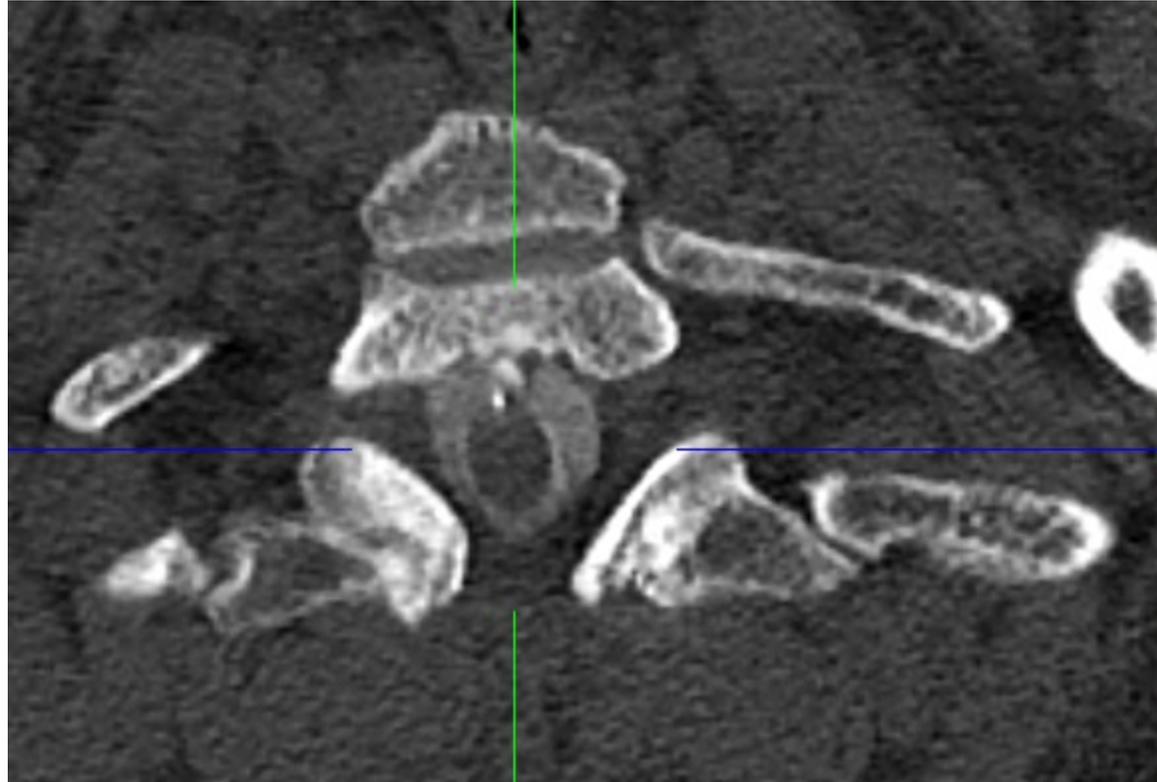
Sanjay Cheema <sup>1,2</sup>, Jane Anderson,<sup>3</sup> Heather Angus-Leppan <sup>4</sup>, Paul Armstrong,<sup>5</sup> David Butteriss,<sup>6</sup> Lalani Carlton Jones,<sup>7,8</sup> David Choi,<sup>1,9</sup> Amar Chotai,<sup>6</sup> Linda D'Antona <sup>1,9</sup>, Indran Davagnanam,<sup>1,10</sup> Brendan Davies,<sup>11</sup> Paul J Dorman,<sup>12</sup> Callum Duncan,<sup>13</sup> Simon Ellis,<sup>11</sup> Valeria Iodice,<sup>1,14</sup> Clare Joy,<sup>15</sup> Susie Lagrata,<sup>2</sup> Sarah Mead,<sup>15</sup> Danny Morland,<sup>16</sup> Justin Nissen,<sup>17</sup> Jenny Pople,<sup>15</sup> Nancy Redfern,<sup>16</sup> Parag P Sayal,<sup>9</sup> Daniel Scoffings,<sup>18</sup> Russell Secker,<sup>15</sup> Ahmed K Toma,<sup>1,9</sup> Tamsin Trevarthen,<sup>15</sup> James Walkden,<sup>19</sup> Jürgen Beck,<sup>20</sup> Peter George Kranz,<sup>21</sup> Wouter Schievink,<sup>22</sup> Shuu-Jiun Wang,<sup>23,24</sup> Manjit Singh Matharu <sup>1,2</sup>

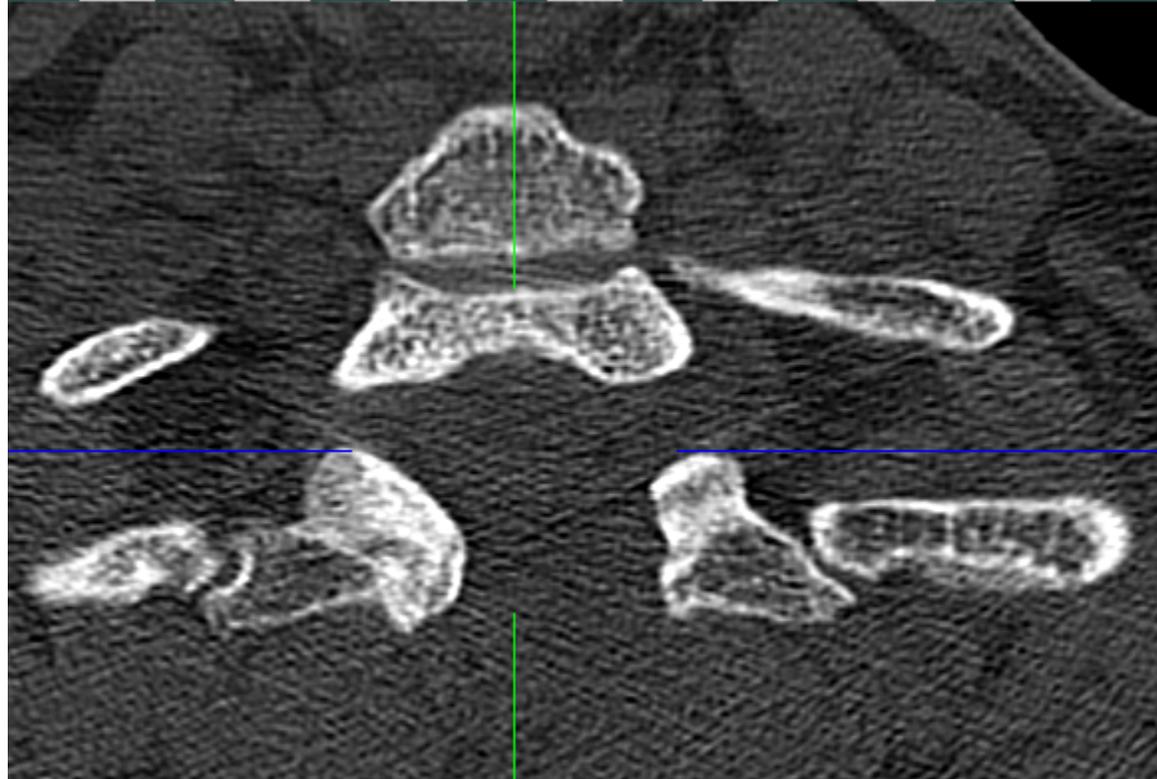


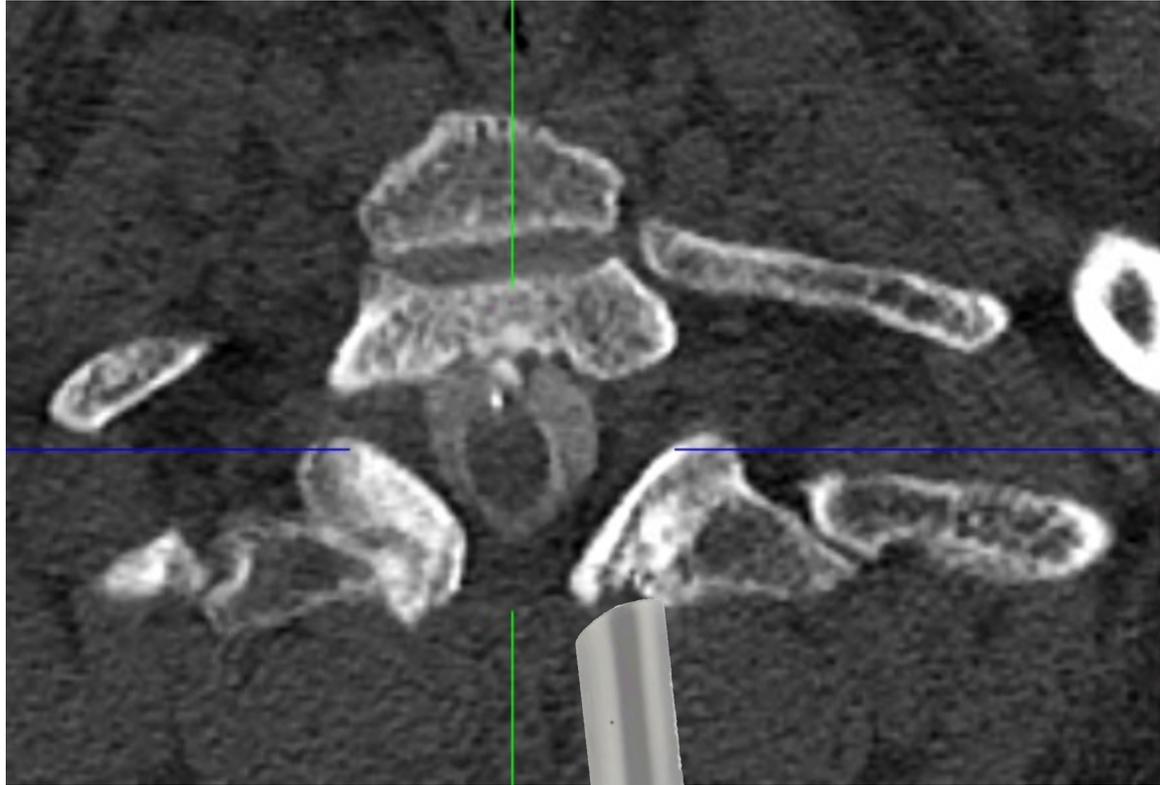
# Anatomy for Surgery

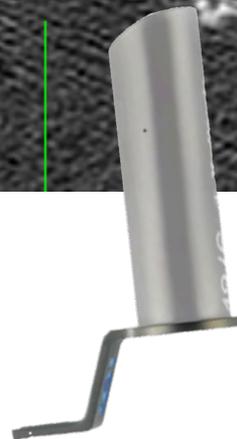
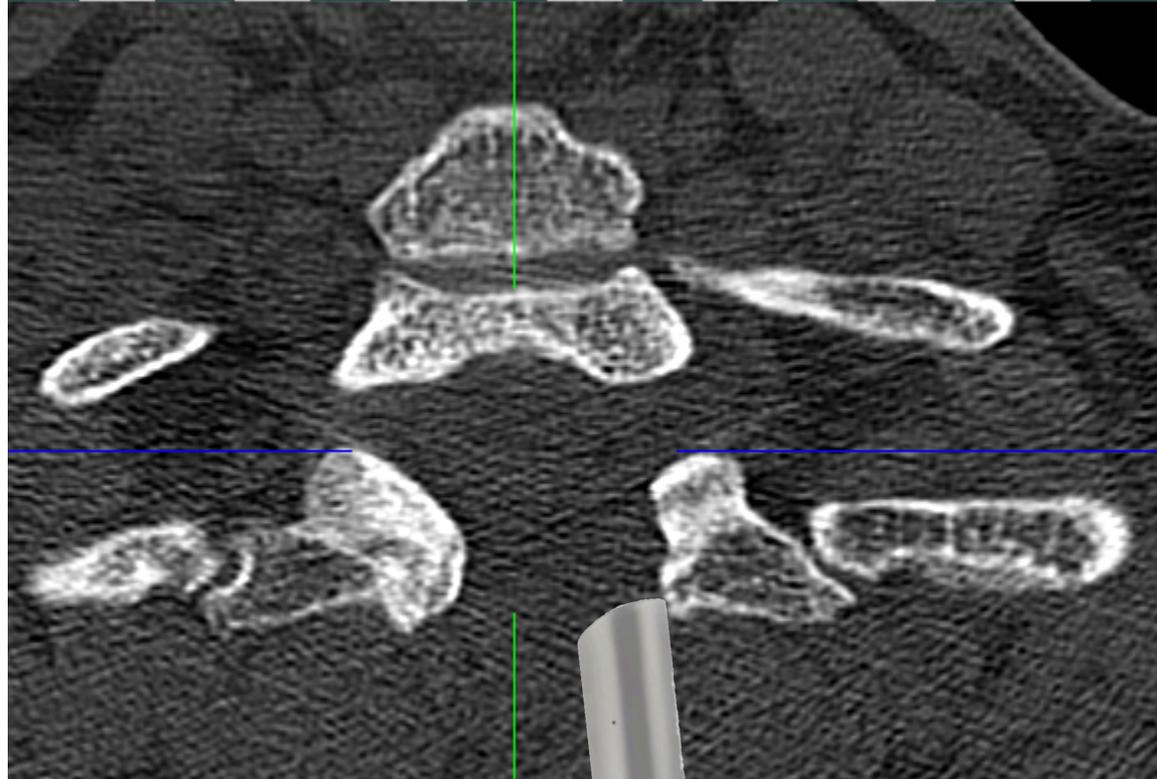


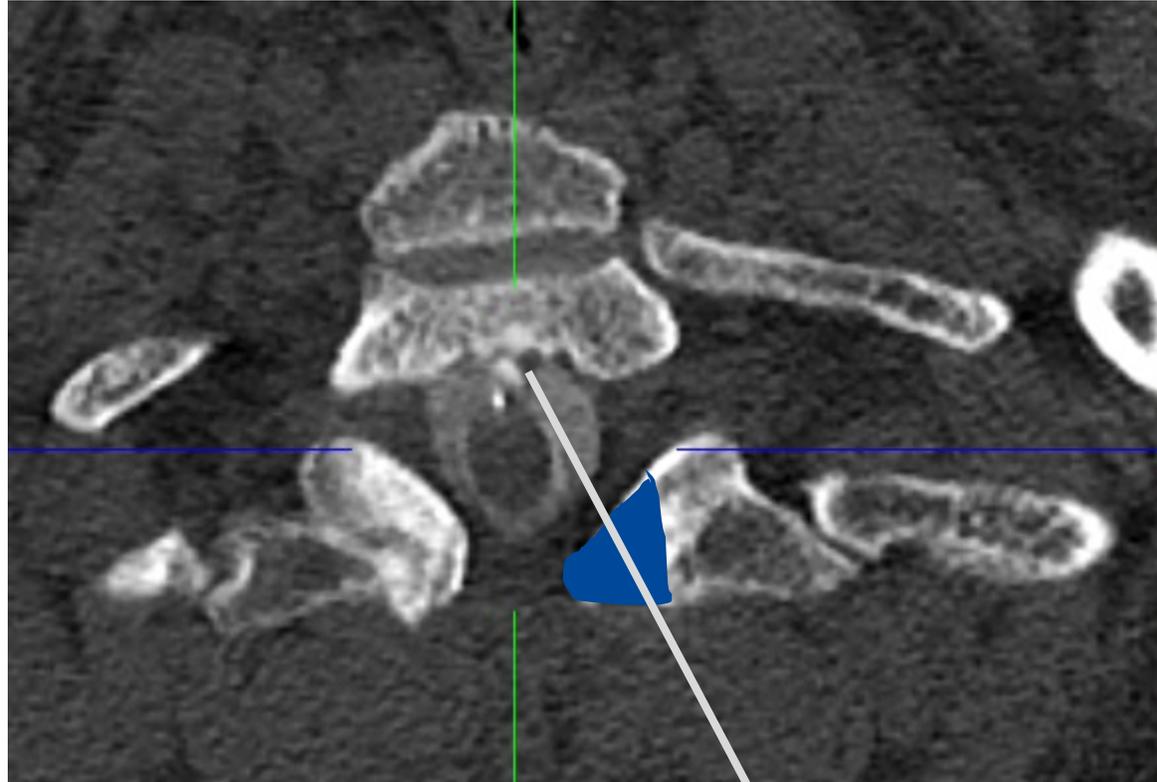






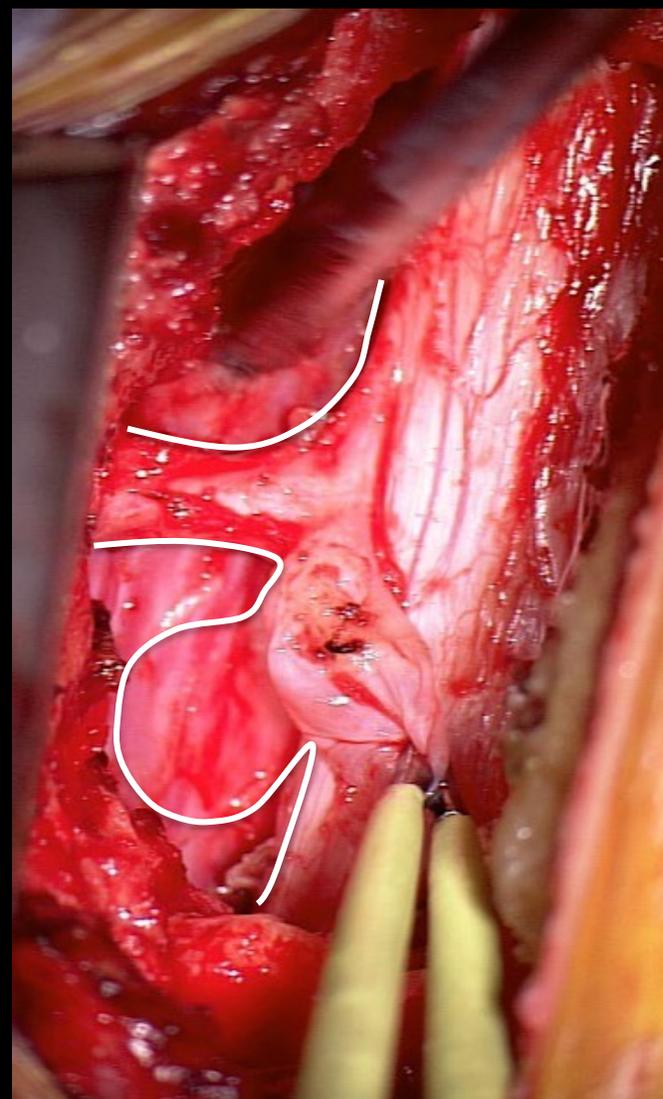
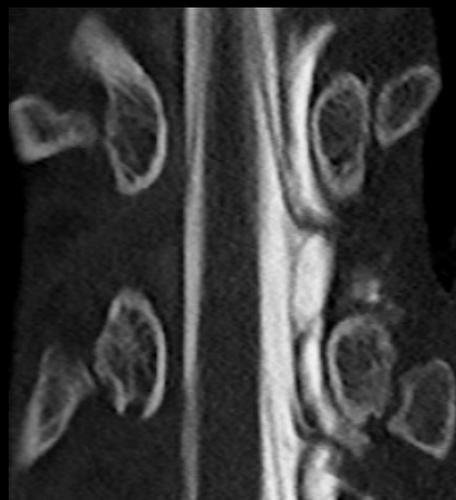






trajectory for  
minimal invasive surgery

# Spinal meningeal diverticula (cyst)



# Intracranial Hypotension Symposium 2025

Amsterdam, the Netherlands, June 28-29



# Intracranial Hypotension Symposium – 2025

Amsterdam,  
The Netherlands  
June 28 – 29





Niederlande

Deutschland

Belgien

Luxemburg

Tschechien

Slowakei

Bn Freiburg im Breisgau

Österreich

Ungarn

Bn Bern

Frankreich

Slowenien

Kroatien

Bosnien und Herzegowina

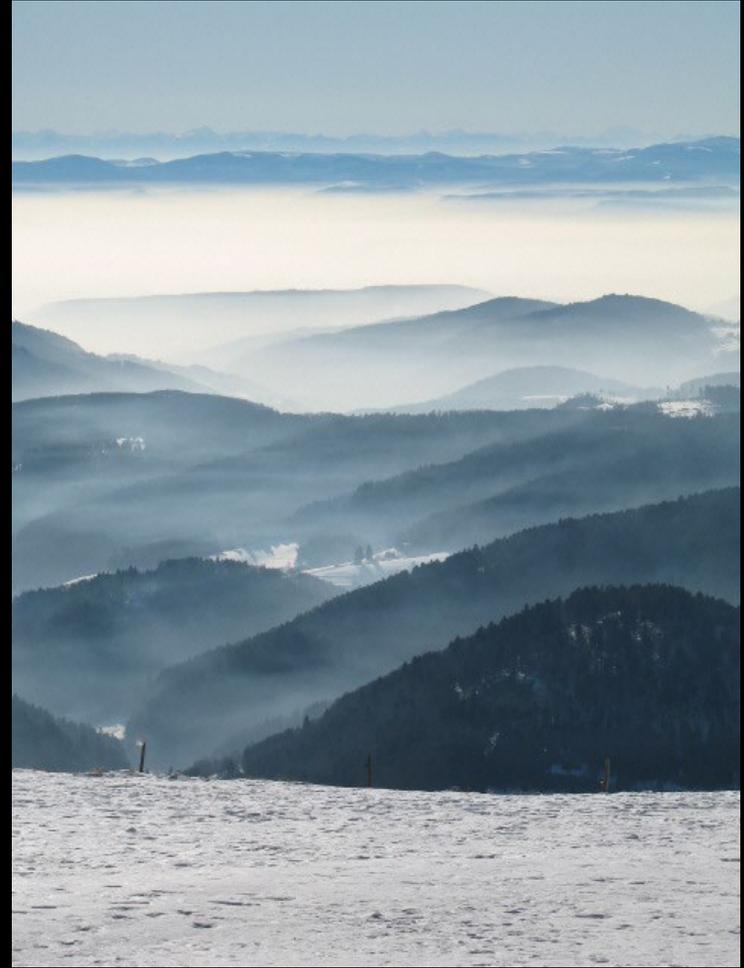
Serbien

Monaco

Italien

Montenegro

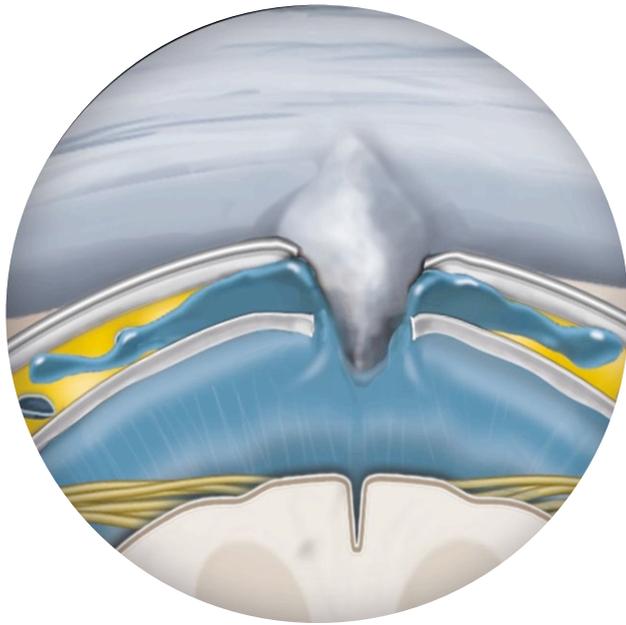
Kosovo





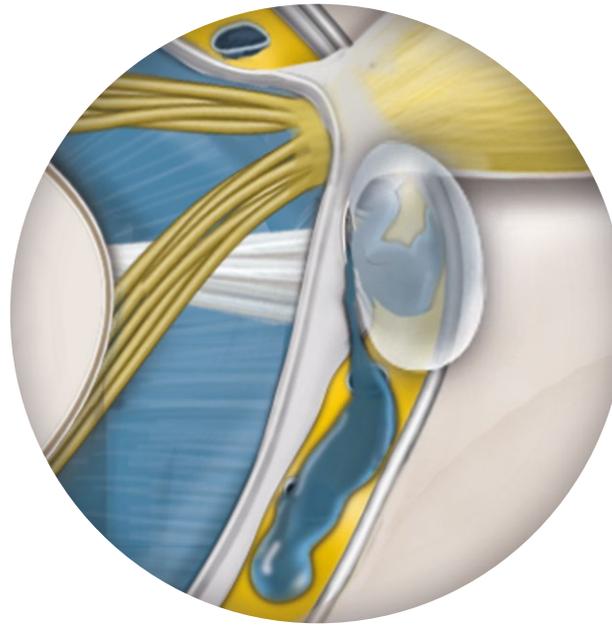
# Spinal dural leaks

Type 1



ventral leak

Type 2



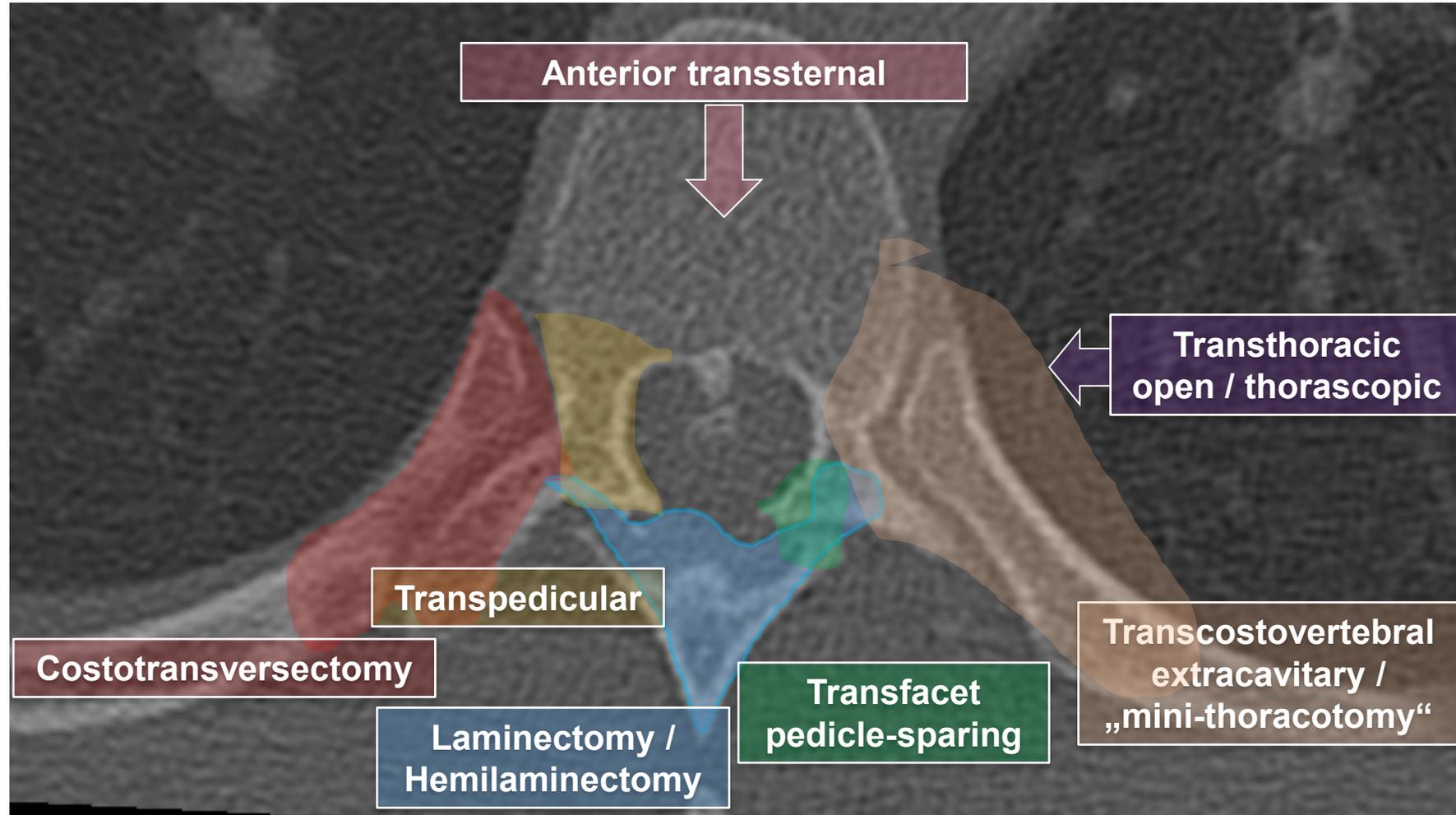
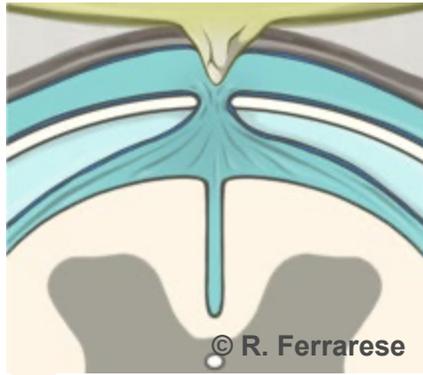
lateral leak

Type 3

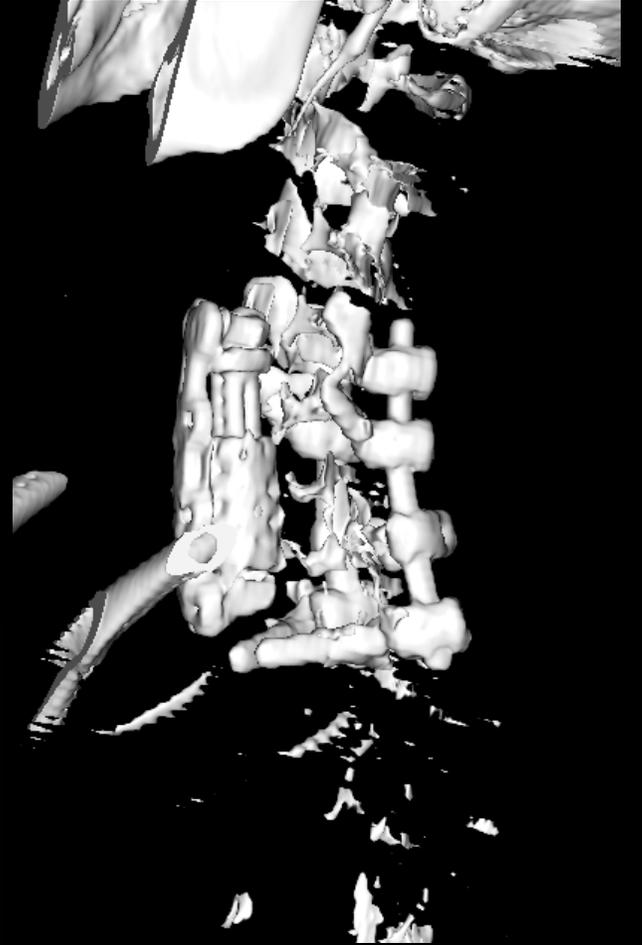
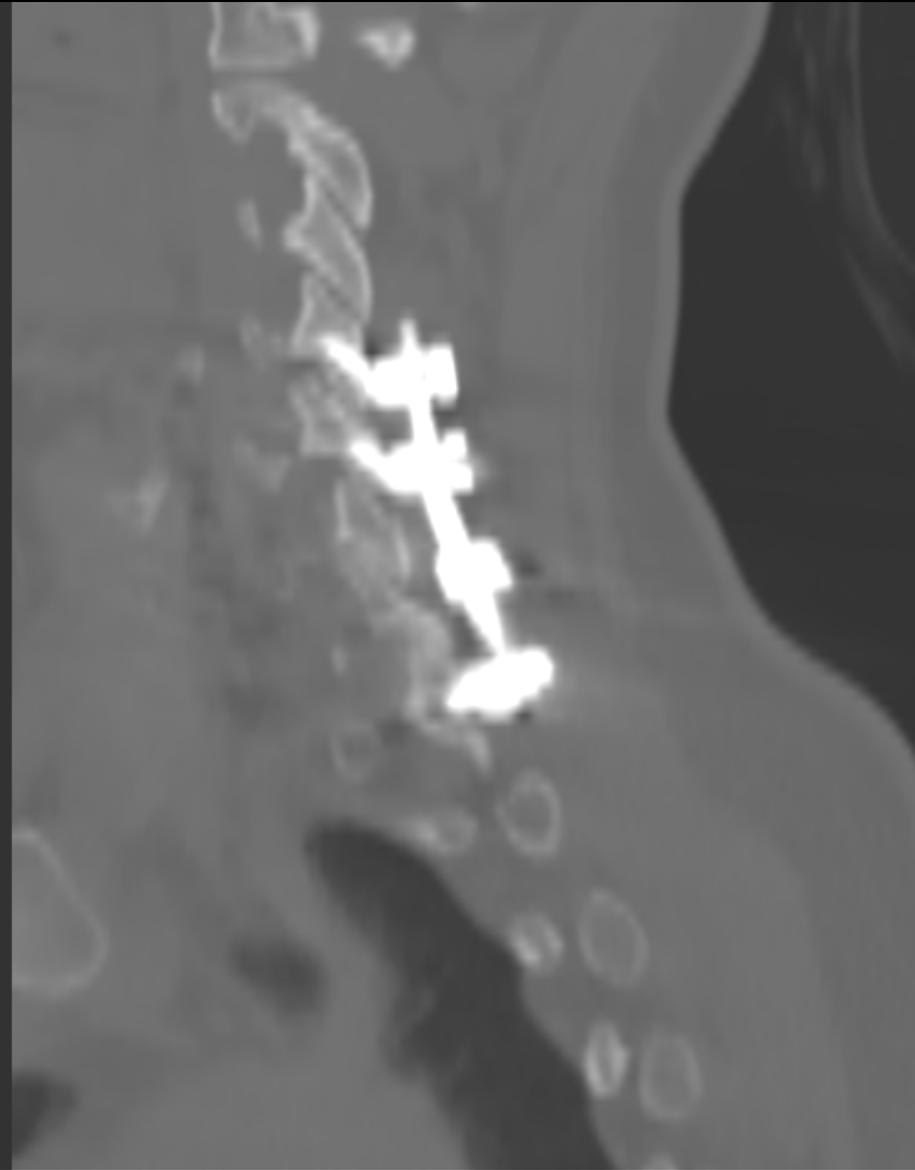


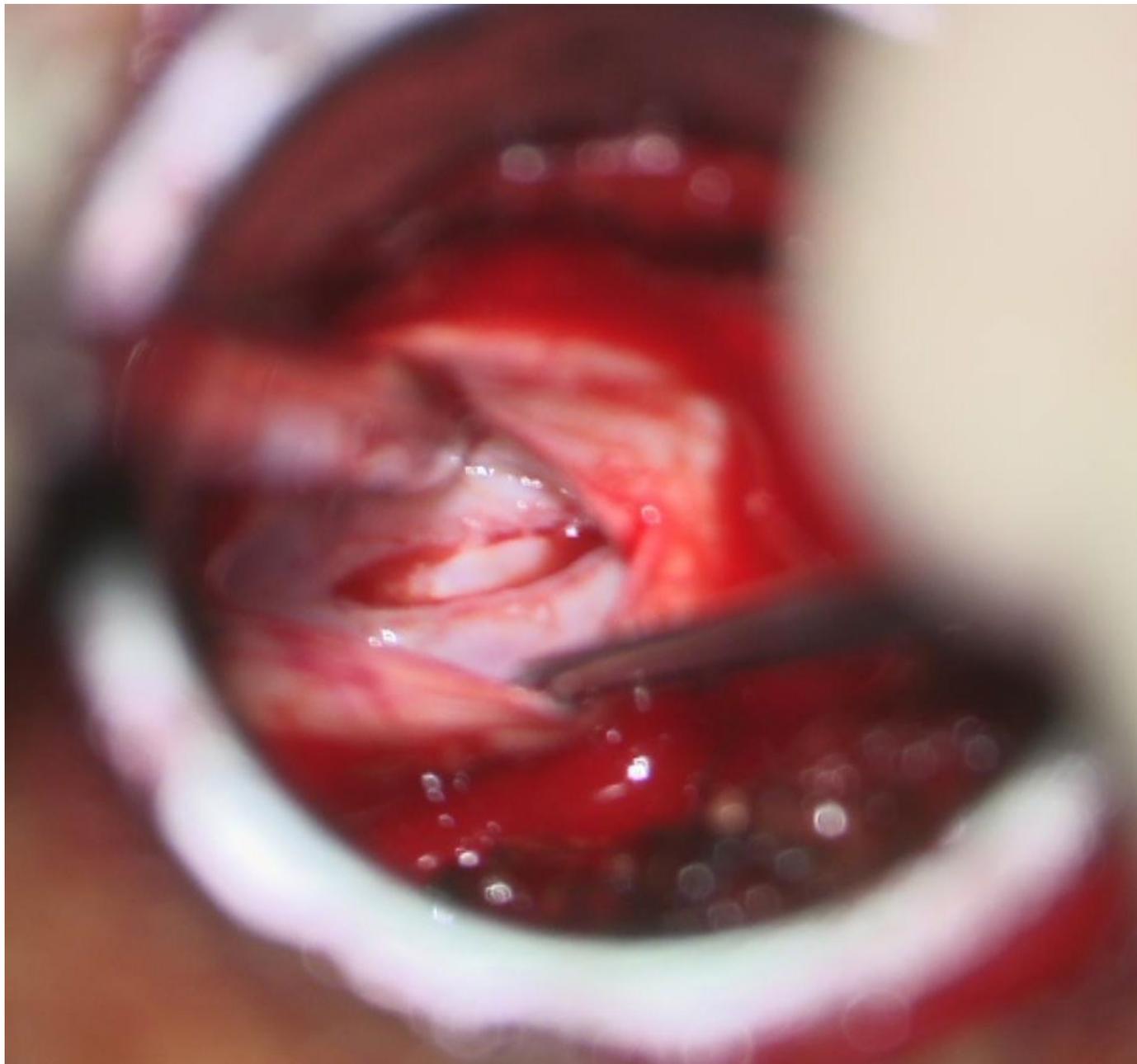
CSF-venous fistula

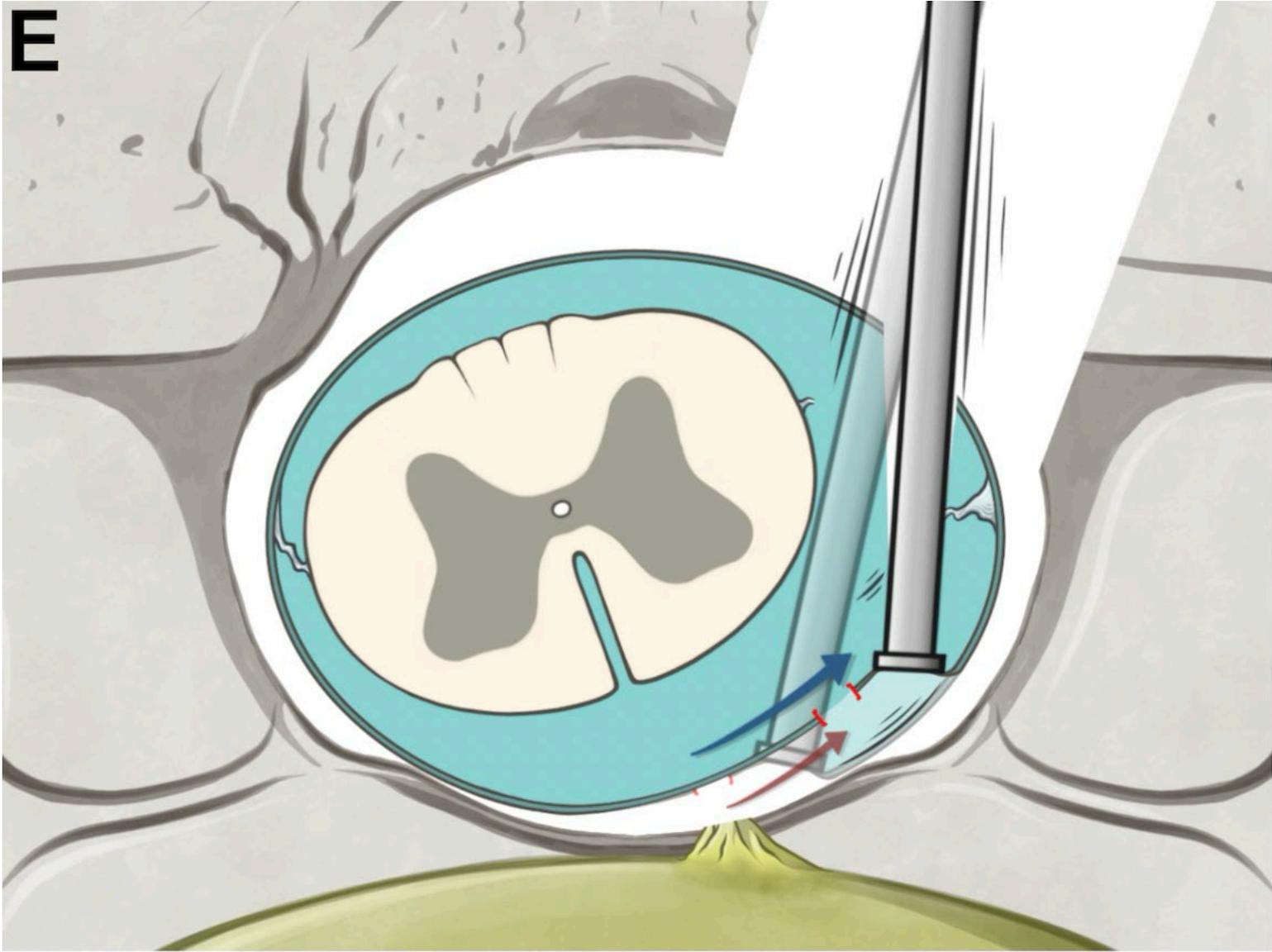
# Ventral leaks → ← Thoracic disk herniation



Diskogenic microspurs as a major cause of intractable spontaneous intracranial hypotension *Neurology*® 2016;87:1220-1226



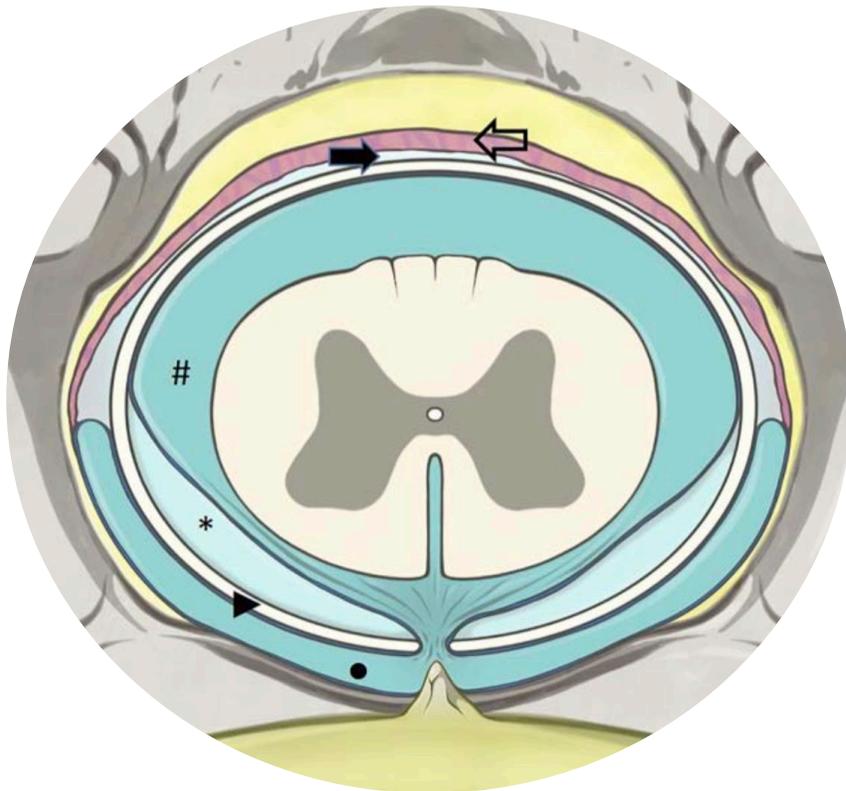




OPEN

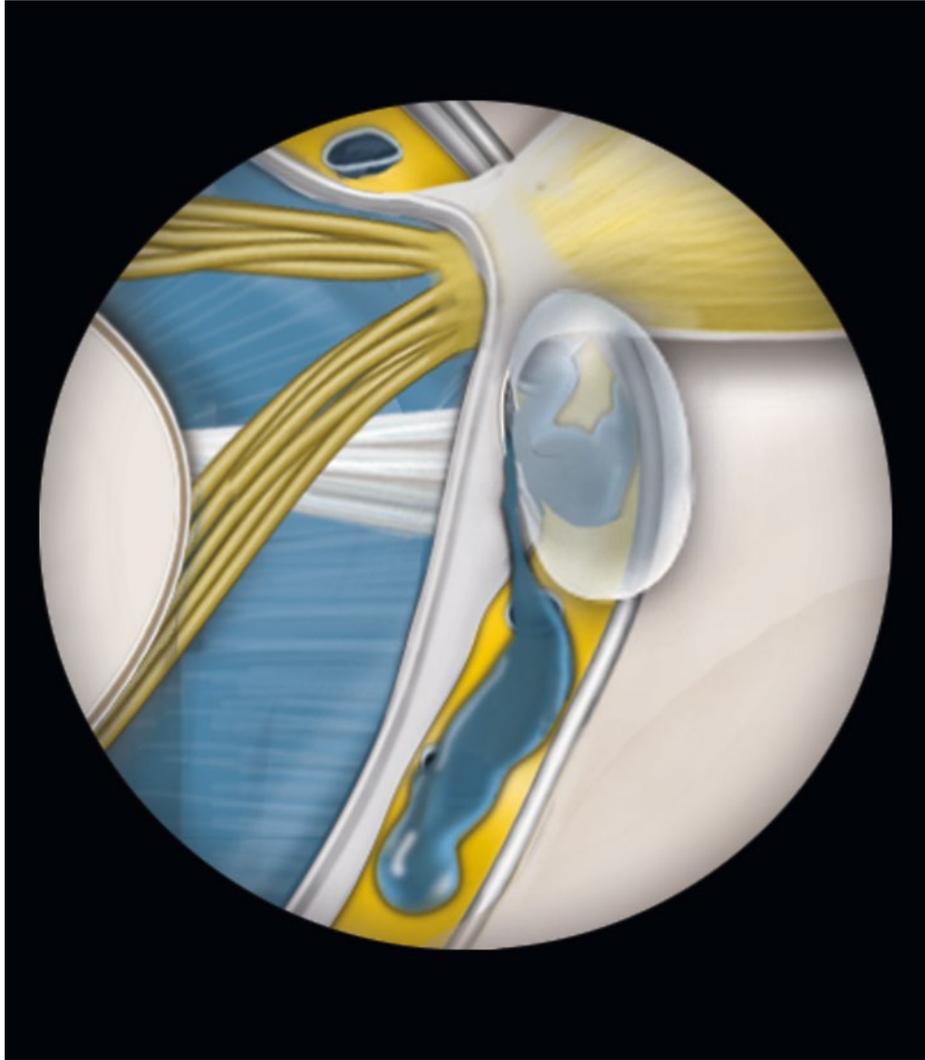
## Distinct Pattern of Membrane Formation With Spinal Cerebrospinal Fluid Leaks in Spontaneous Intracranial Hypotension

Levin Häni, MD \*\*, Christian Fung, MD\*\*, Amir El Rahal, MD<sup>§</sup>, Florian Volz, MD<sup>‡</sup>, Luisa Mona Kraus, MD<sup>‡</sup>, Oliver Schnell, MD<sup>‡</sup>, Roberto Ferrarese, PhD<sup>‡</sup>, Daniel Erny, MD<sup>||</sup>, Marius Schwabenland, MD<sup>§</sup>, Horst Urbach, MD<sup>¶</sup>, Niklas Lützen, MD<sup>¶</sup>, Jürgen Beck, MD<sup>‡</sup>



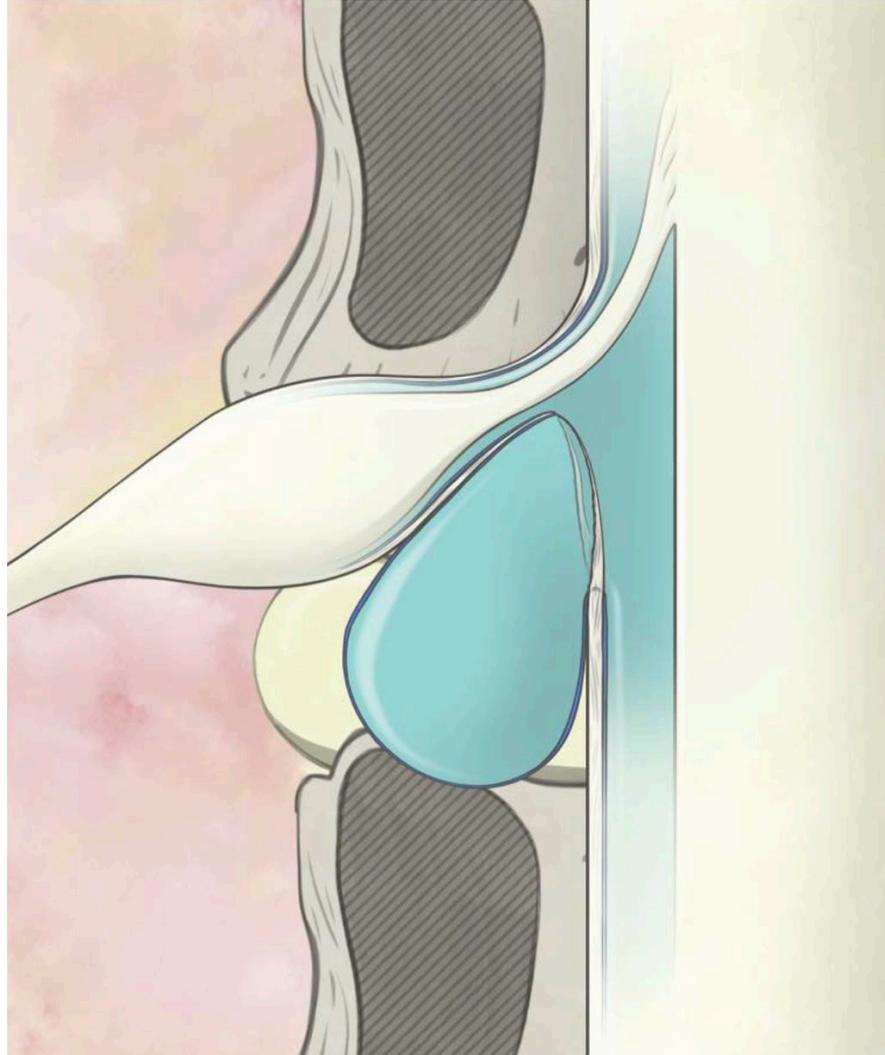
- Dorsal membranes – neo dura
  - Lateral membranes – herniated arachnoid - SLEC
  - Funnel like transdural channel – herniated arachnoid
  - Lateral membrane – cysts/diverticula – at axilla of or around the exiting nerve root
- 
- Formation of membranes or herniation of arachnoid
  - Specific patho-anatomic feature of SIH
  - Paramount importance for diagnosis and treatment

**... all about membranes**



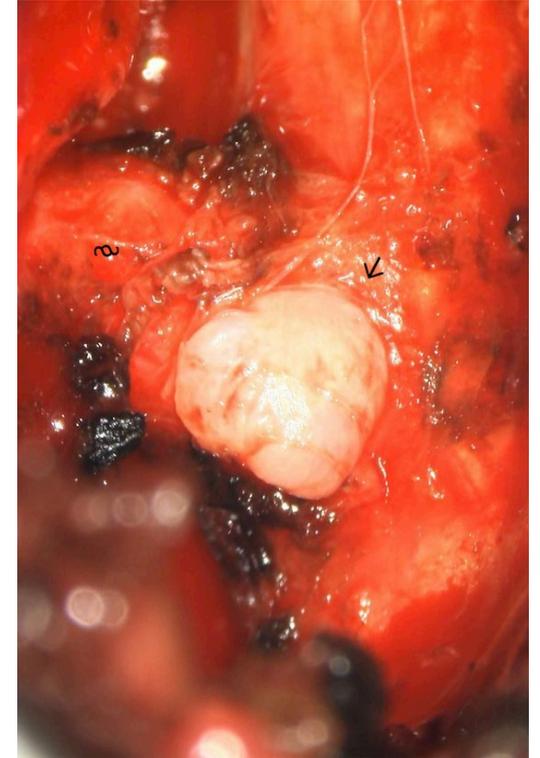
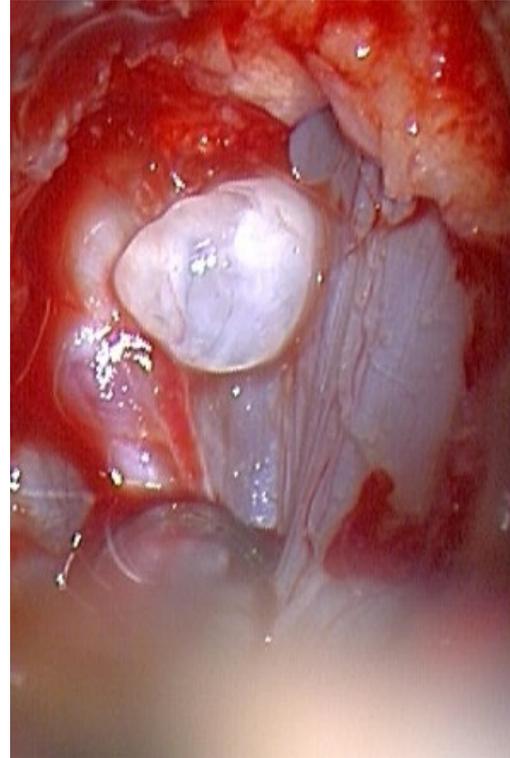
## Lateral spinal CSF-leaks

- spinal meningeal diverticula (cyst)
- outpouched arachnoid



**Spinal CSF leak = tear in the dura**

**Microsurgical anatomy  
lateral membranes = arachnoid (diverticula)**



*Häni et al. Operative Neurosurgery 2023*

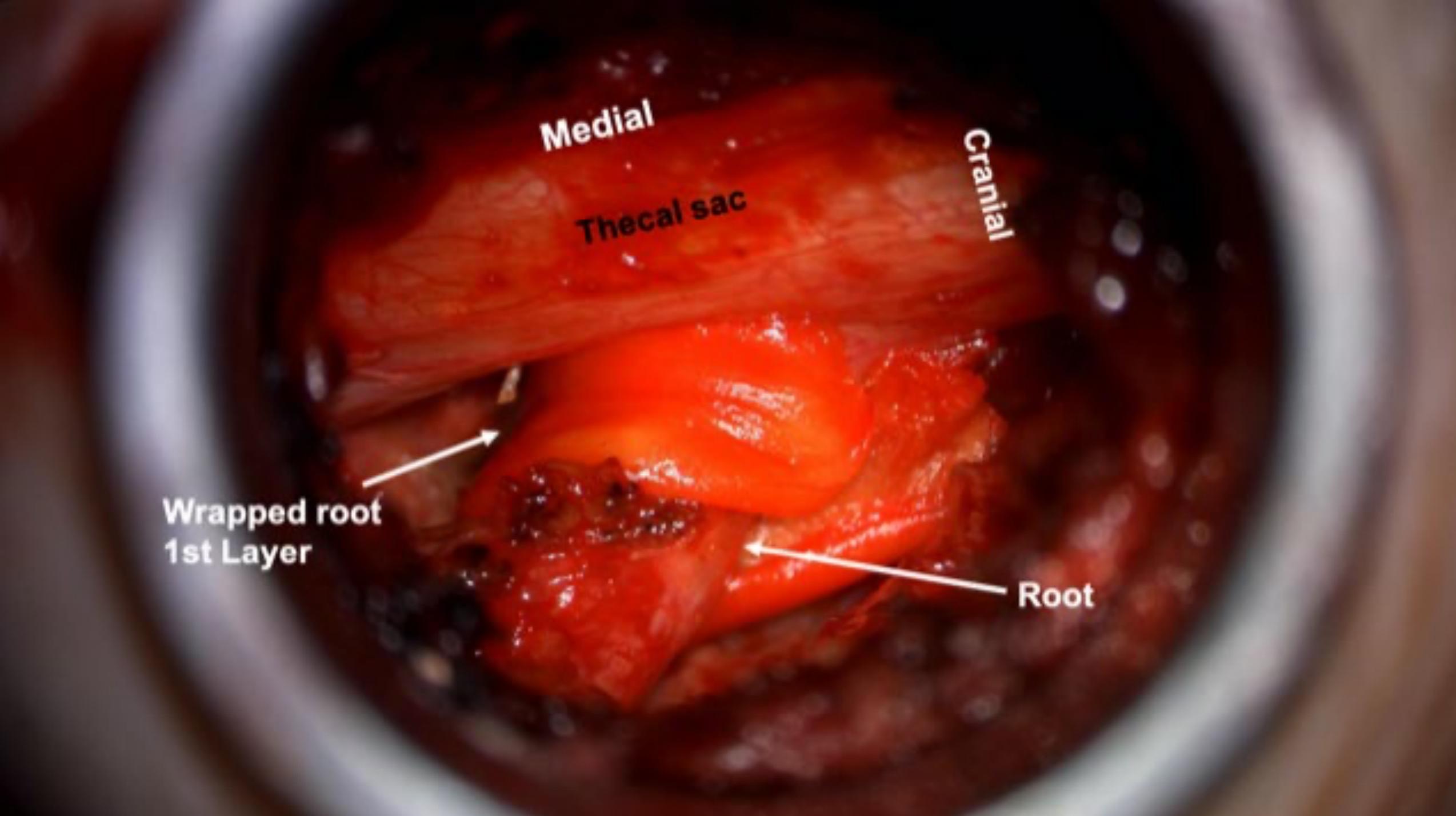
**Medial**

**Thecal sac**

**Cranial**

**Wrapped root  
1st Layer**

**Root**



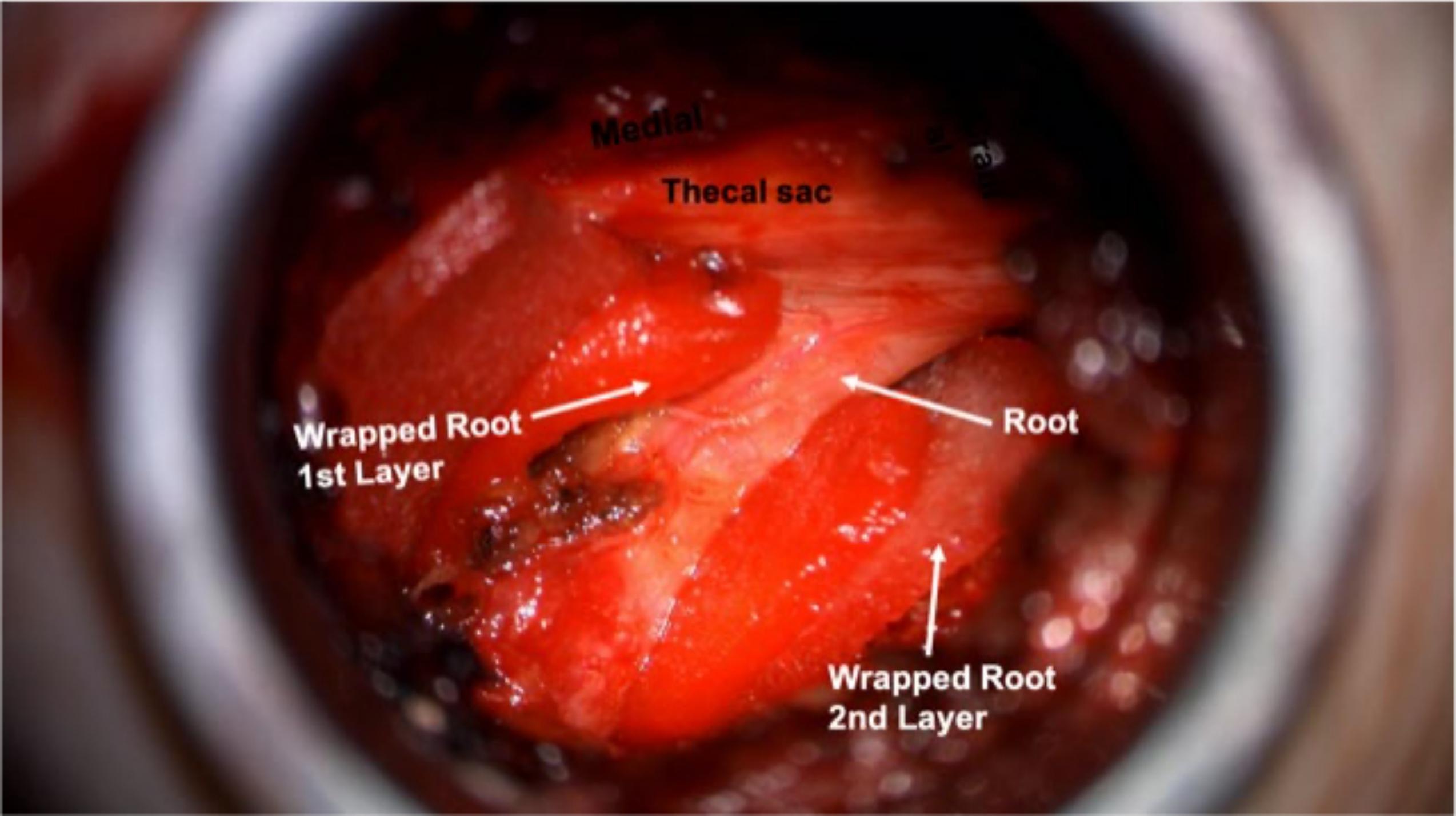
Medial

Thecal sac

Wrapped Root  
1st Layer

Root

Wrapped Root  
2nd Layer



**Medial**

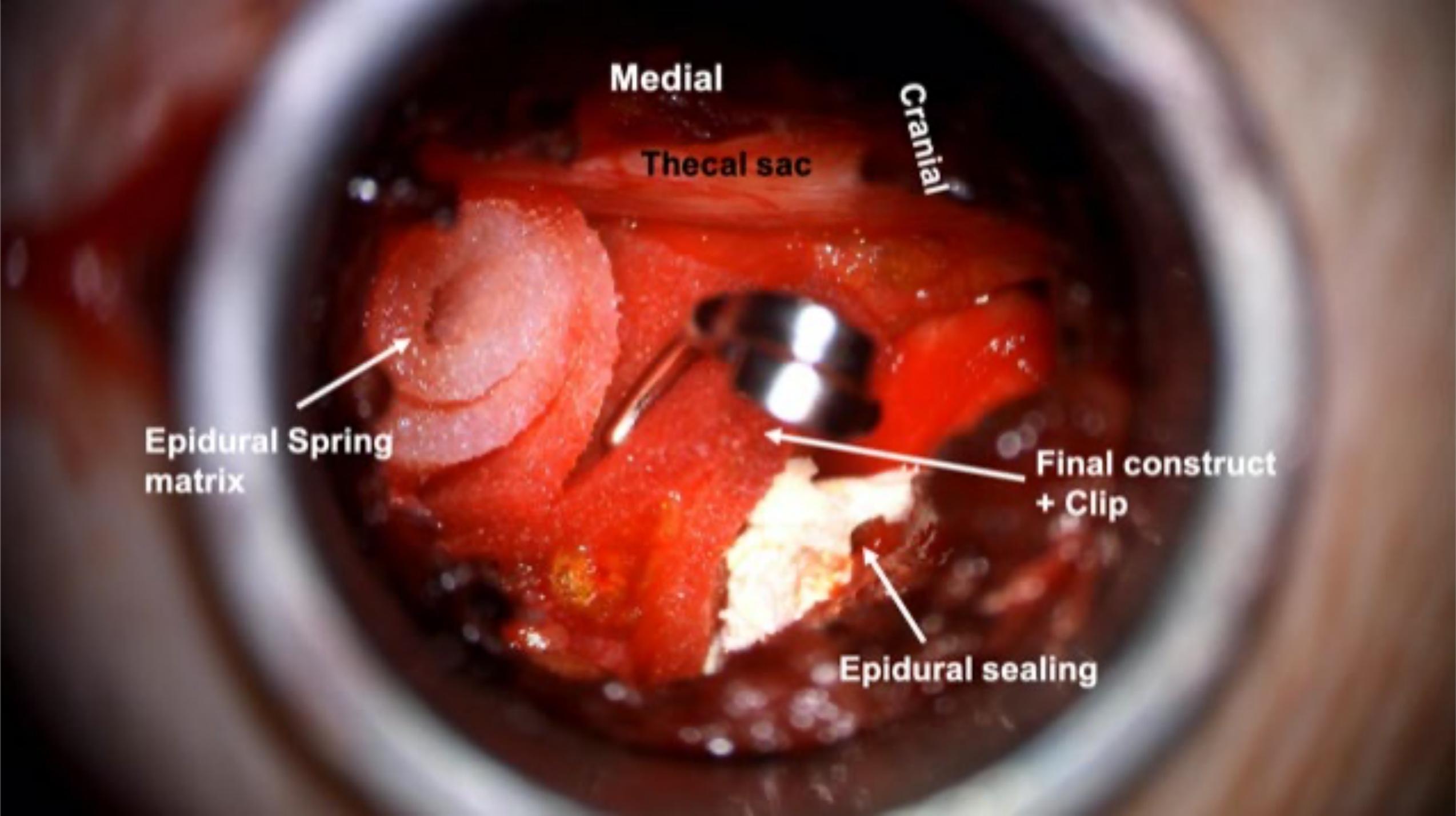
**Cranial**

**Thecal sac**

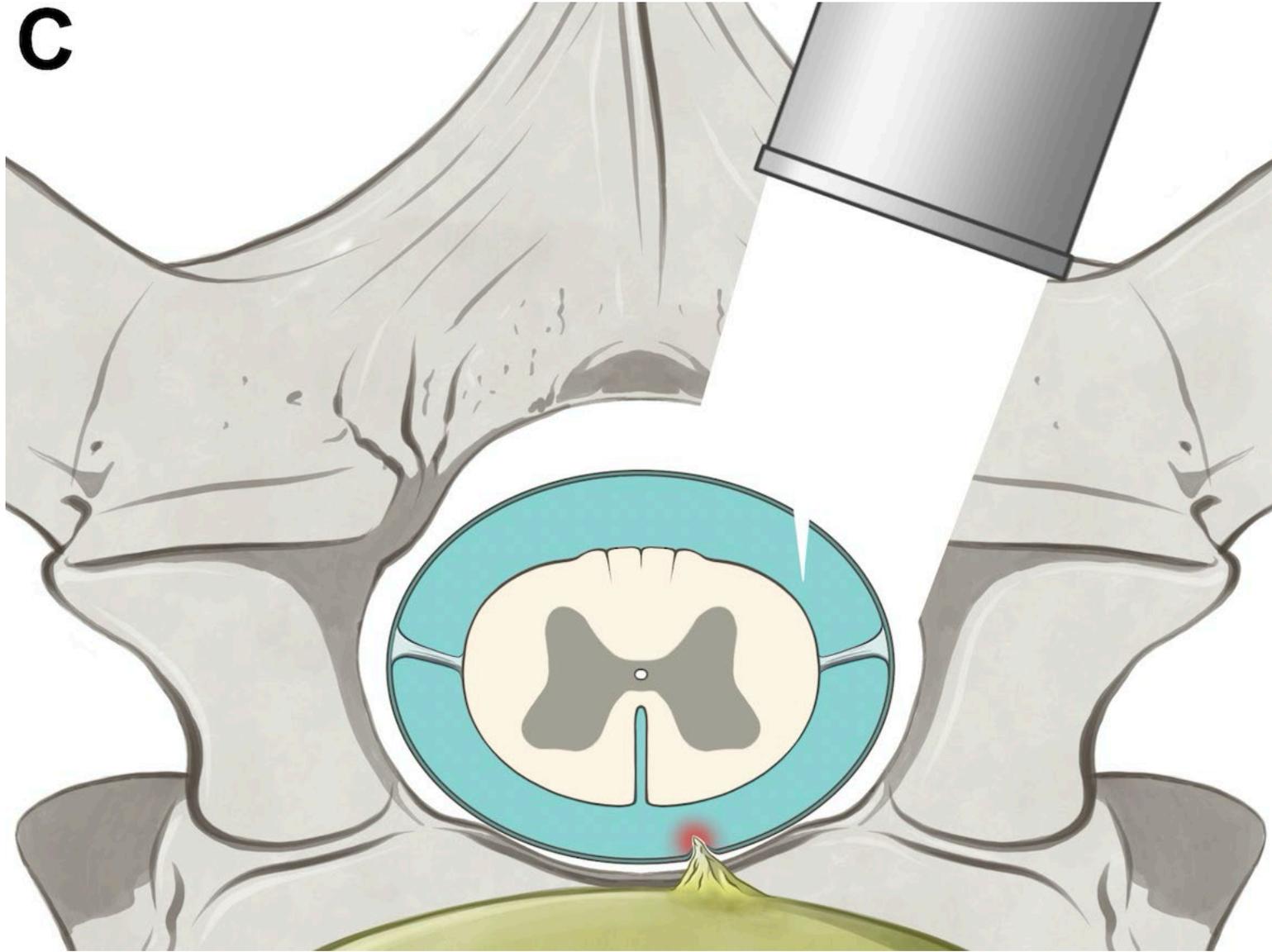
**Epidural Spring  
matrix**

**Final construct  
+ Clip**

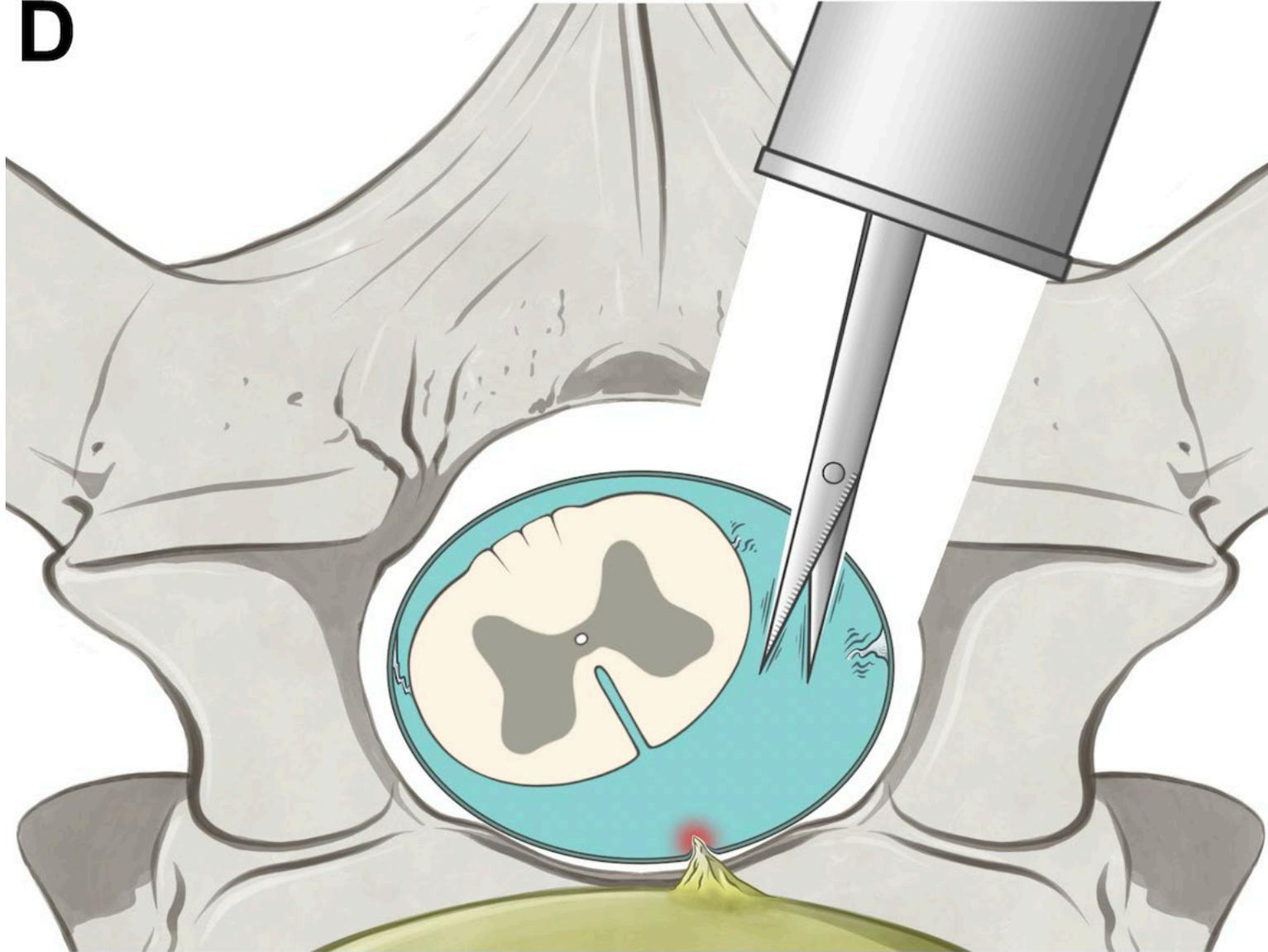
**Epidural sealing**

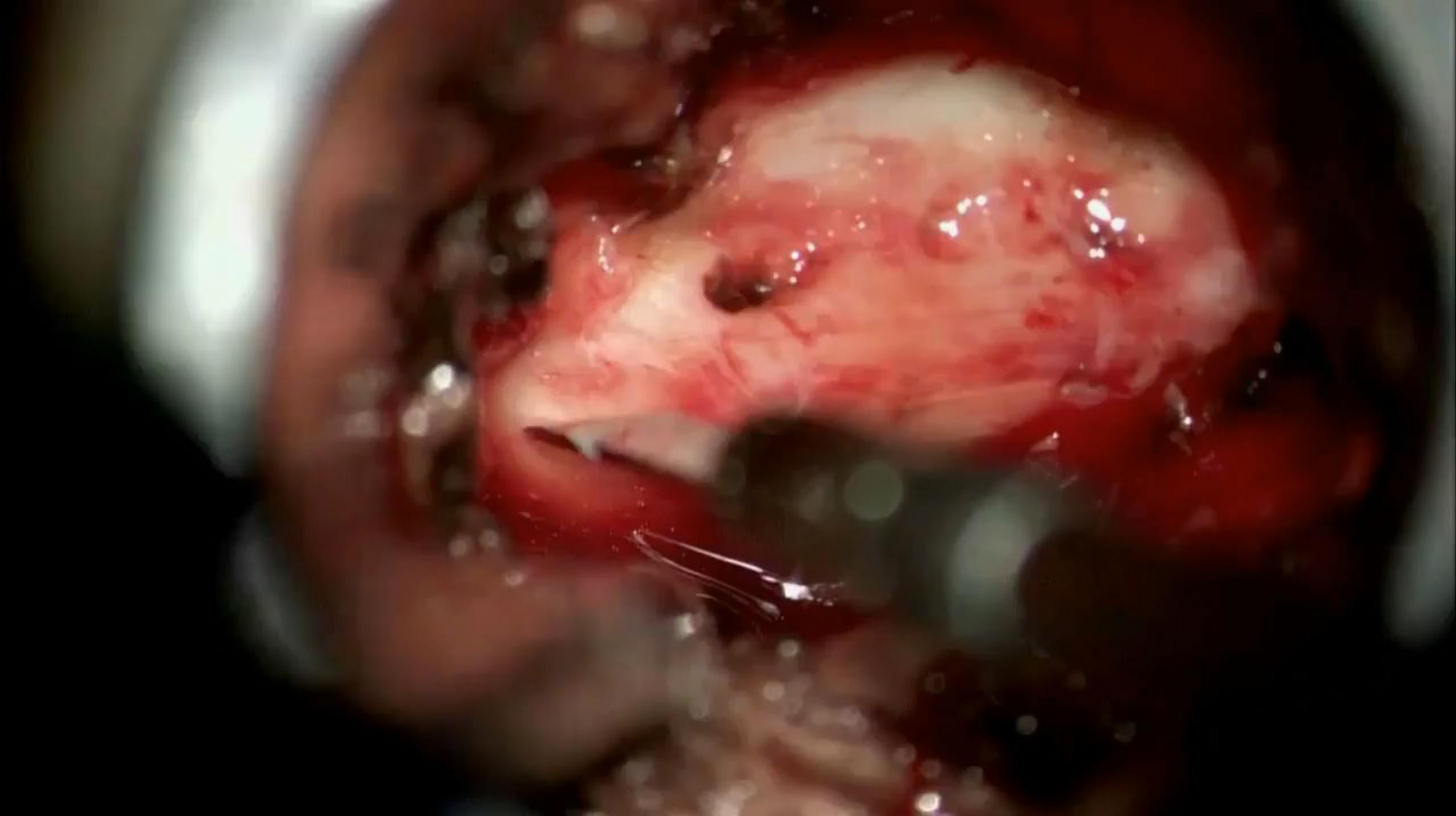


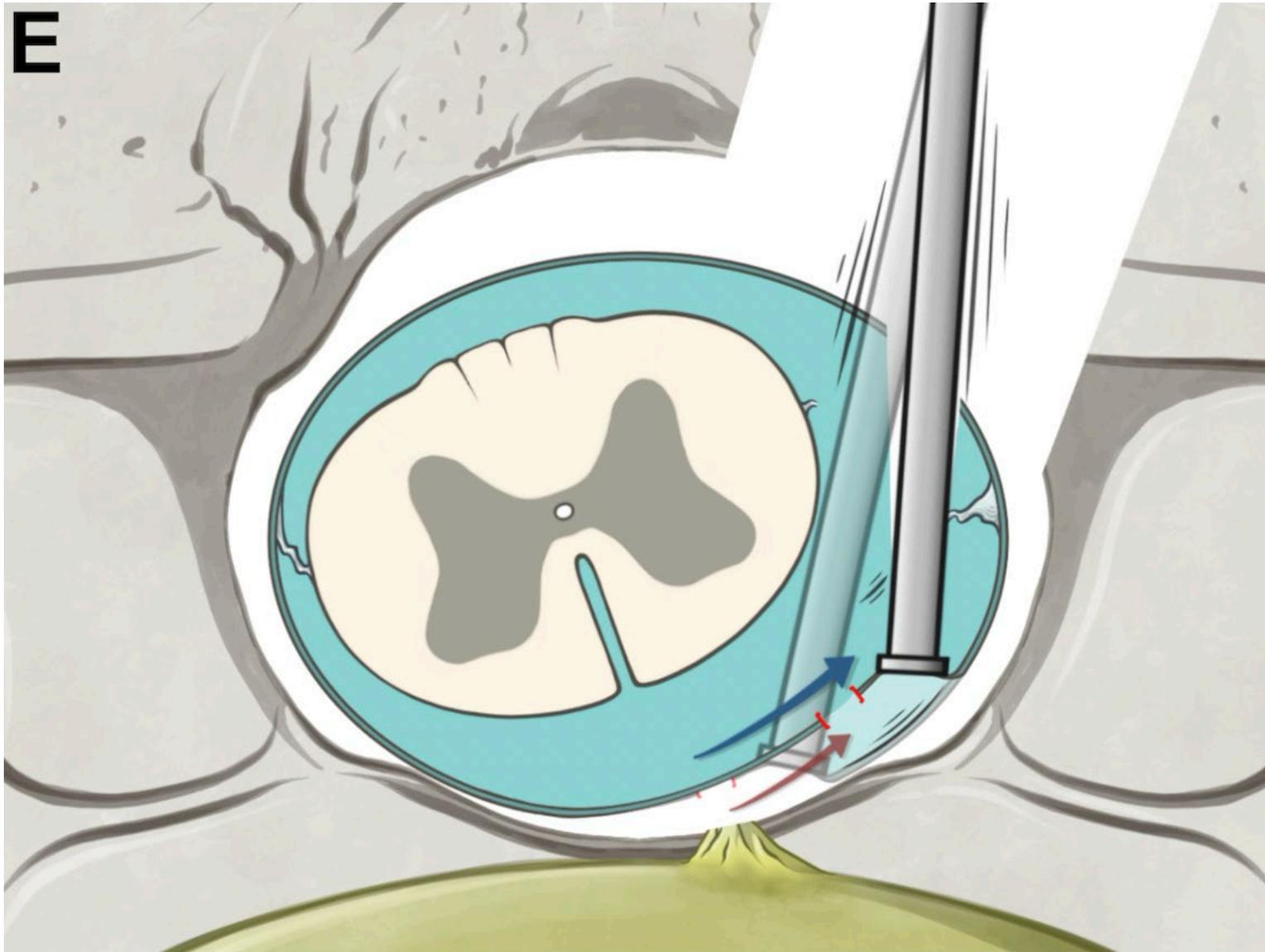
C

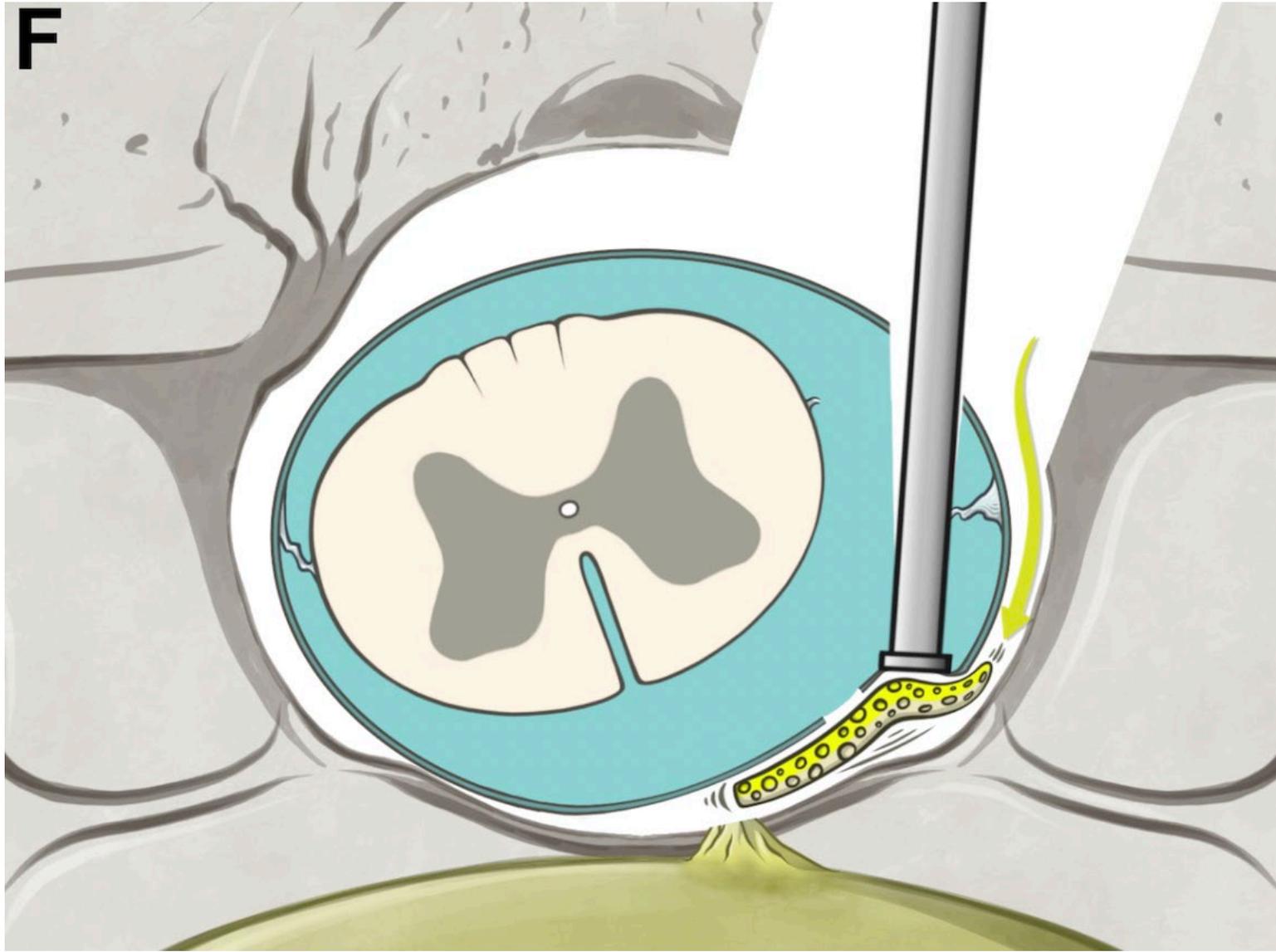


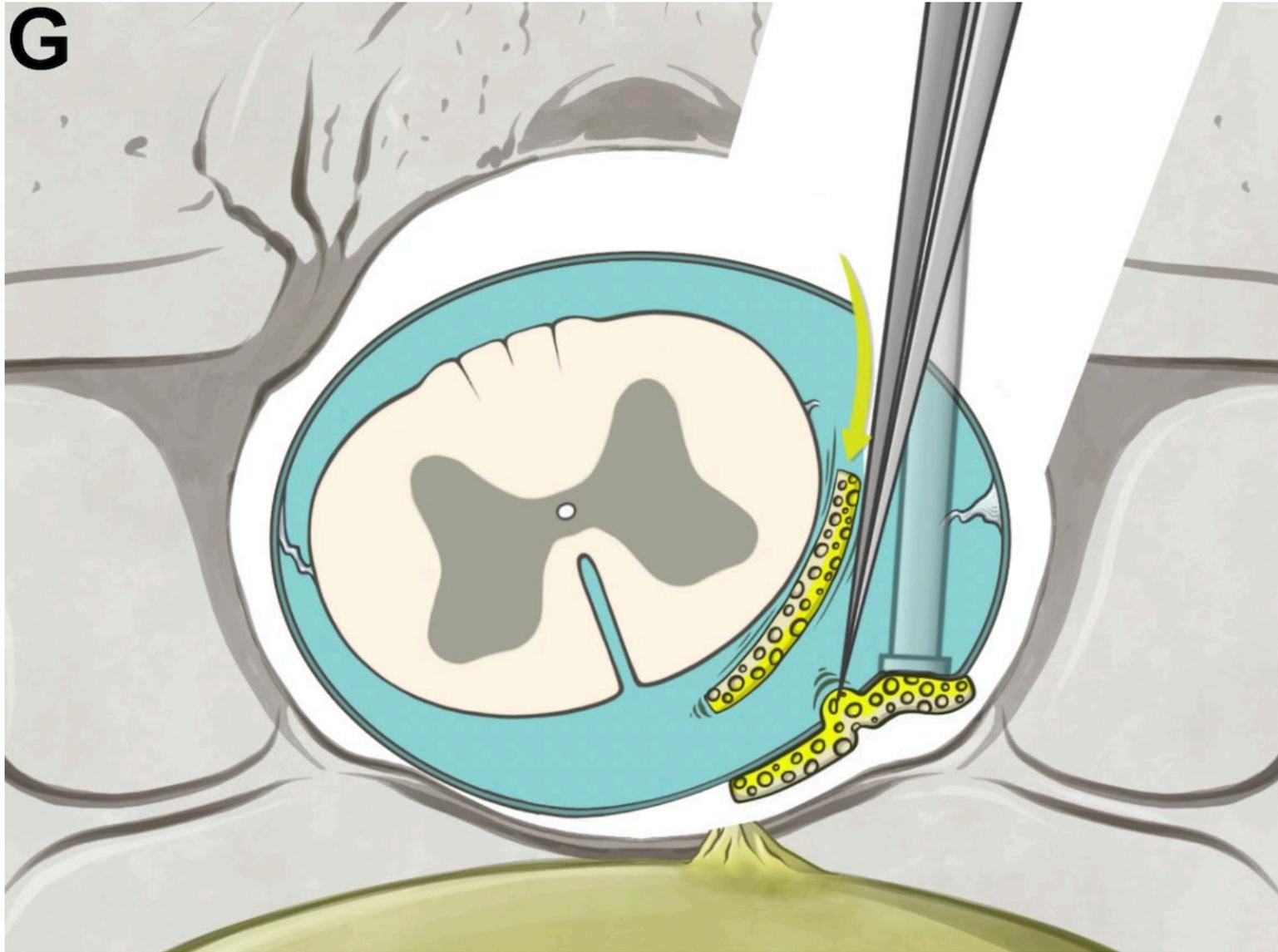
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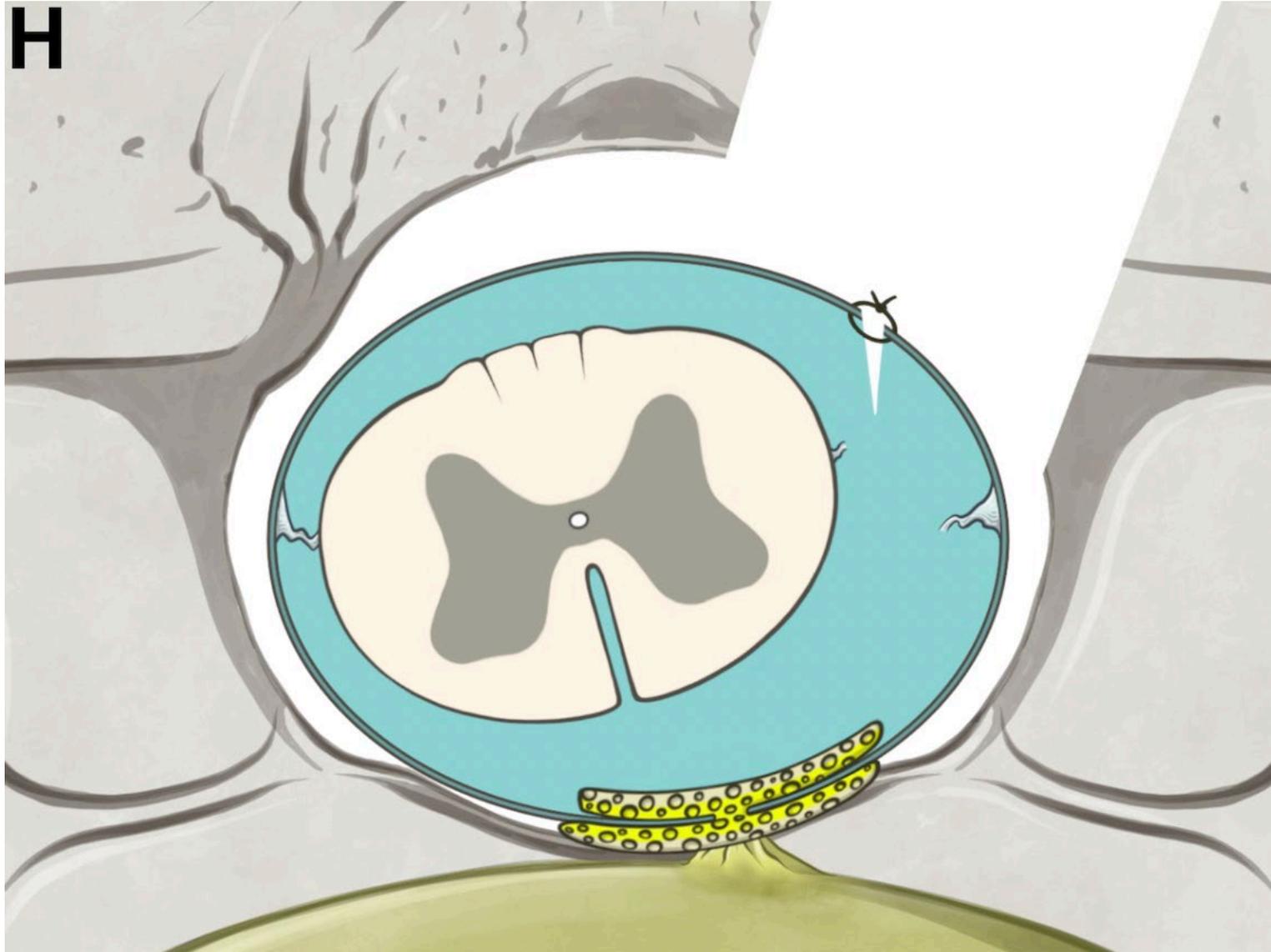


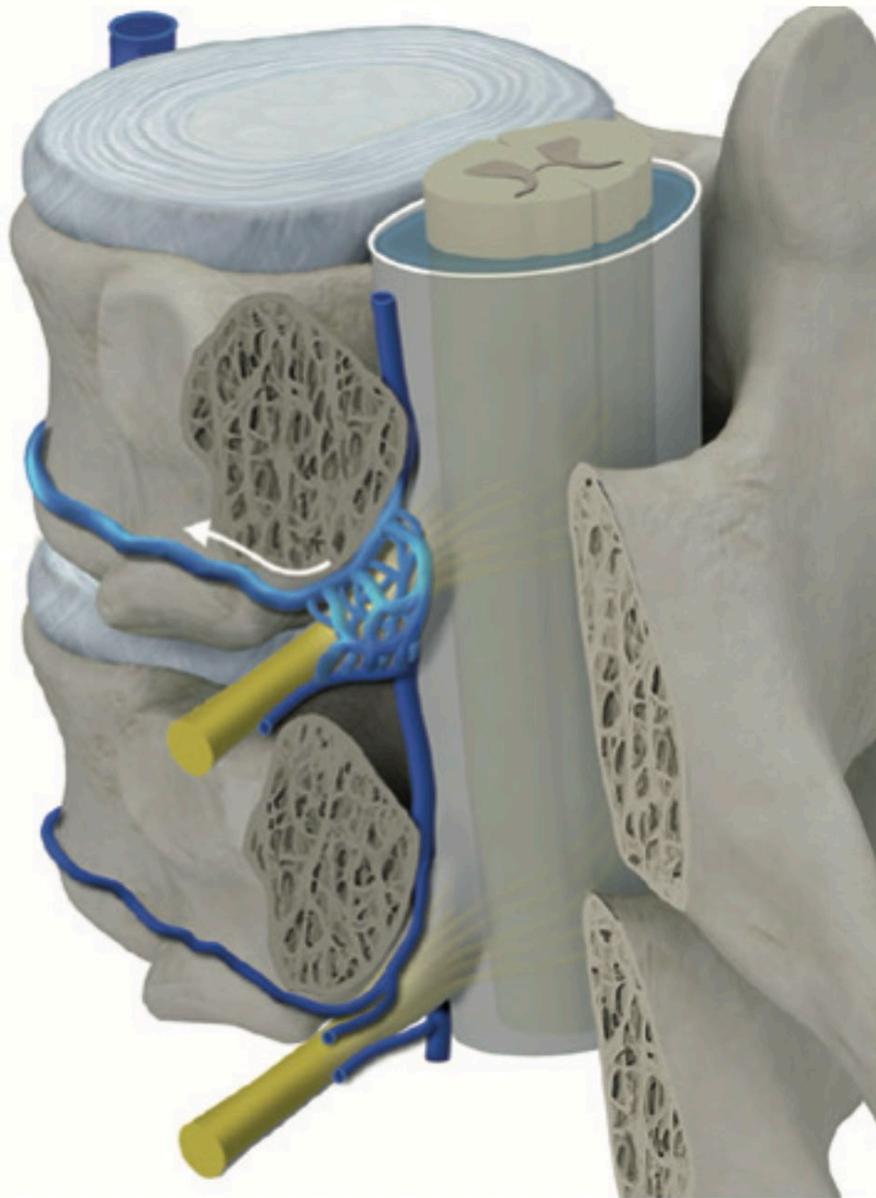












## CSF-venous fistula

Dobrocky et al. Beck *Lancet Neurol* 2022