CERVICAL SPINE SURGERY:
APPROACH RELATED OUTCOME

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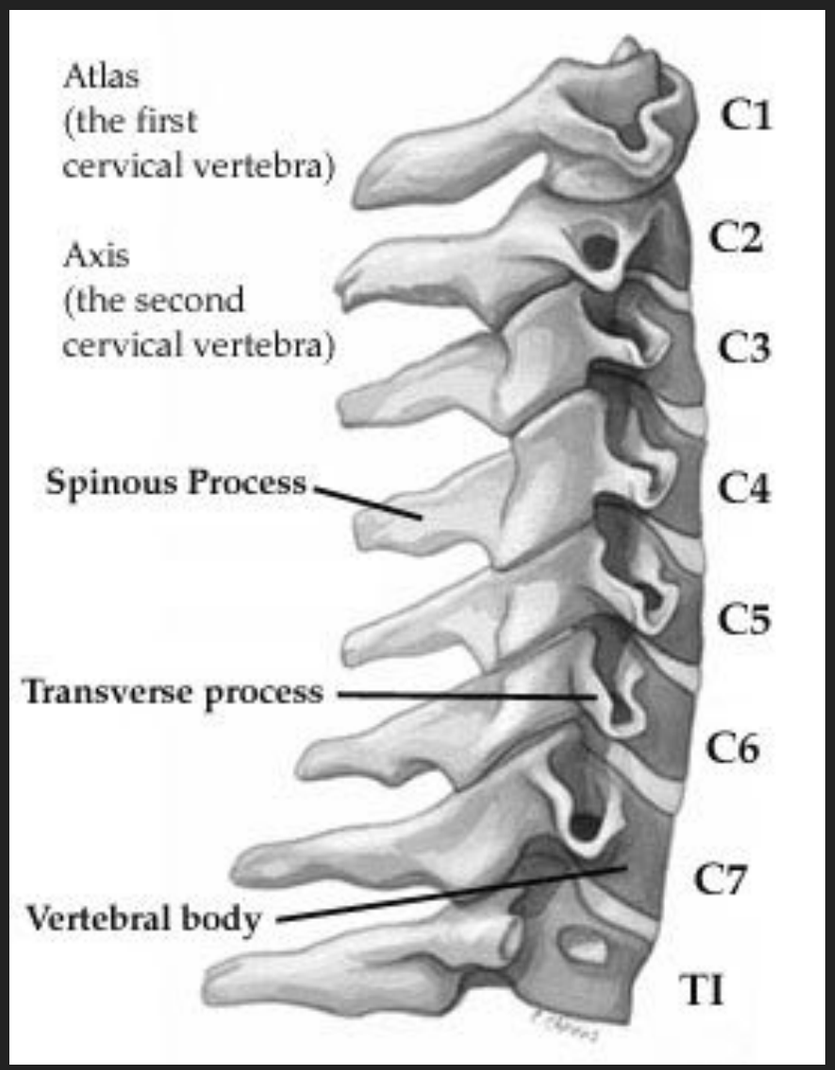
CERVICAL SPINE

- The cervical spine is divided into the **Axial Spine** (C1-C2) and the **Subaxial Spine** (C3-C7).
- Biomechanically different.
- The Canal diameter narrows caudally along the vertebrae.



CERVICAL PATHOLOGIES

Multiple etiologies:

- Degenerative (spondylosis)
- Trauma
- Vascular
- Rheumatologic
- Congenital
- Neoplastic
- Idiopathic
- Iatrogenic

CERVICAL SPINE TREATMENT

Spine (Phila Pa 1976). 2000 Mar 15;25(6):670-6.

Outcome of patients treated for cervical myelopathy. A prospective, multicenter study with independent clinical review.

Sampath P[1], Bendebba M, Davis JD, Ducker TB.

- When medical and surgical treatments are compared, **surgically** treated patients appear to have **better** outcomes, despite exhibiting a greater number of neurologic and nonneurologic symptoms and having greater functional disability before treatment.

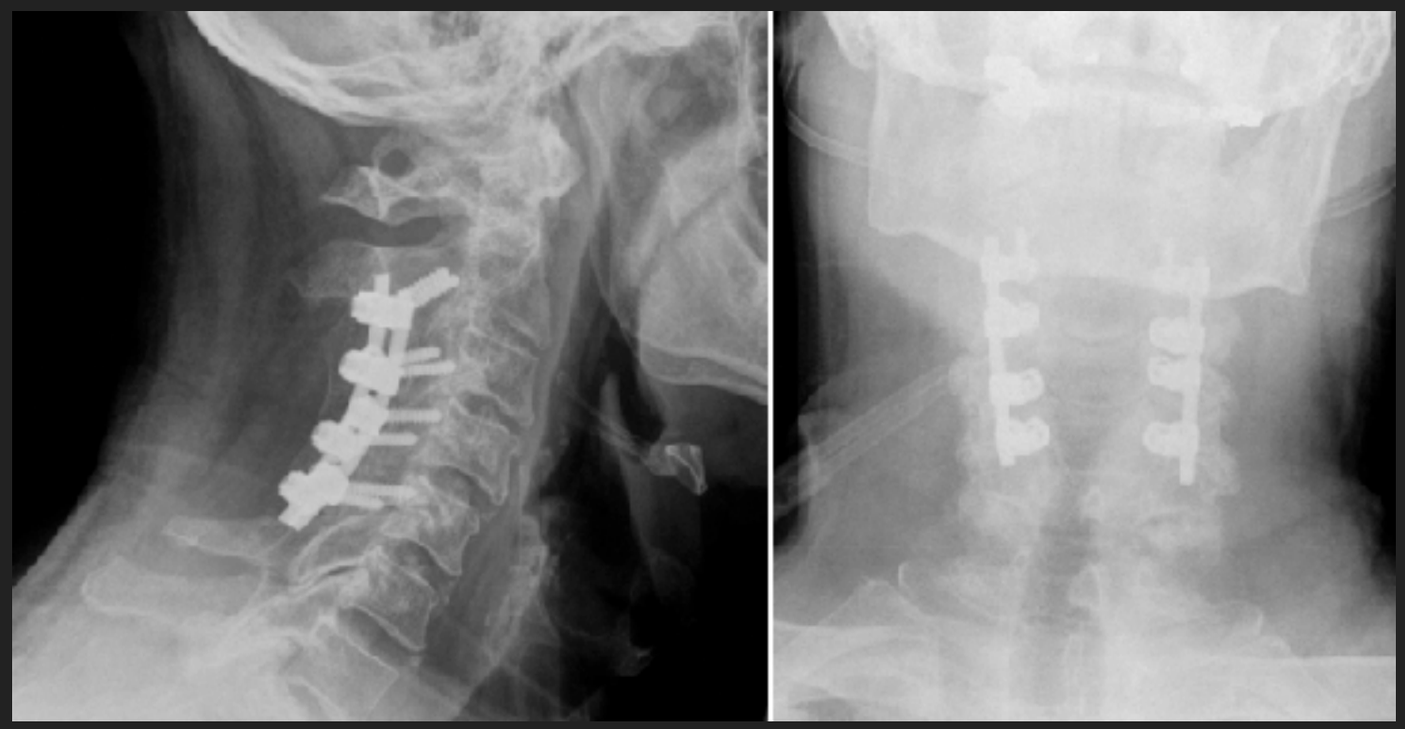
CERVICAL SPINE SURGERIES

There are two surgical approaches for spinal stenosis, trauma or cervical instability treatment:

- Posterior approach.
- Anterior approach.

POSTERIOR APPROACH

- Includes laminectomy and laminoplasty.
- Used for decompression of the cord.
- This method was described at the beginning of the last century.



POSTERIOR APPROACH

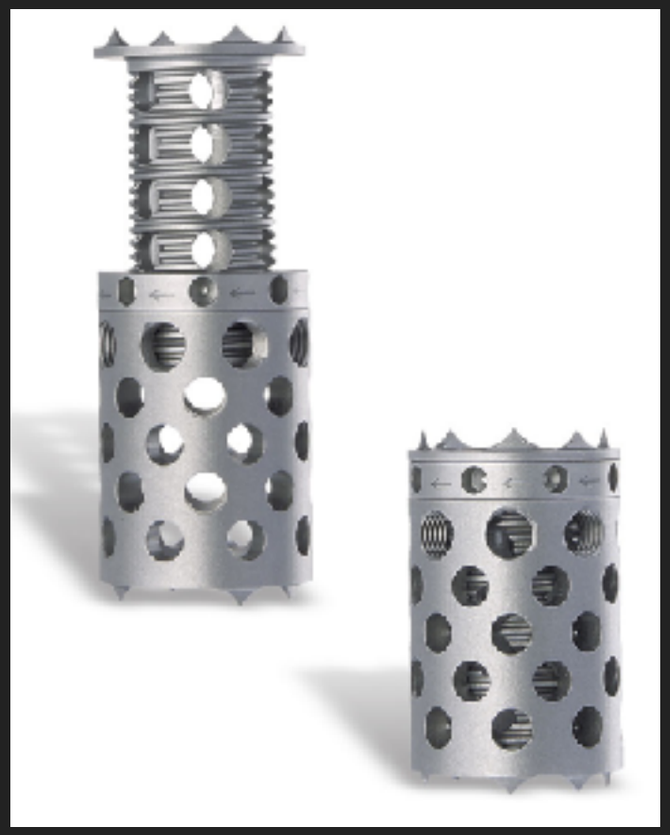
- Over the last few decades the insertion of lateral mass screws evolved so it facilitates the fusion of the cervical spine.
- Nowadays, we have screws, hooks and rods which allow adaptability of the system.

ANTERIOR APPROACH

- Includes cropectomy and/or discectomy.
- Was introduced in 1958, and was heavily criticized by spine surgeons.

ANTERIOR APPROACH

- Insertion of a cage which is placed instead of the vertebra's body that was removed.
- A plate stabilizes the vertebrae thereby increases the fusion rate.



Vertebral Body Reconstruction using Expandable Titanium Cages after Anterior Decompression for Cervical Spondylotic Myelopathy: A Review. Cureus, 2014.

ANT VS. POST

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Comparative Effectiveness of Ventral vs Dorsal Surgery for Cervical Spondylotic Myelopathy

BACKGROUND: Cervical spondylotic myelopathy (CSM) is the most common cause of spinal cord dysfunction.

OBJECTIVE: To determine the feasibility of a randomized clinical trial comparing the clinical effectiveness and costs of ventral vs dorsal decompression with fusion surgery for treating CSM.

METHODS: A nonrandomized, prospective, clinical pilot trial was conducted. Patients ages 40 to 85 years with degenerative CSM were enrolled at 7 sites over 2 years (2007-2009). Outcome assessments were obtained preoperatively and at 3 months, 6 months, and 1 year postoperatively. A hospital-based economic analysis used costs derived from hospital charges and Medicare cost-to-charge ratios.

RESULTS: The pilot study enrolled 50 patients. Twenty-eight were treated with ventral fusion surgery and 22 with dorsal fusion surgery. The average age was 61.6 years. Baseline demographics and health-related quality of life (HR-QOL) scores were comparable be-

- Non randomized, prospective study.
  50 patients: 28 ventral, 22 dorsal.
- Results - Ventral group: **more** neurological improvement, **similar** complications rate, **less** hospital expanses and **shorter** length of stay.

ANT VS. POST

ORIGINAL ARTICLE

CrossMark

Cervical Spine Surgery: Approach-Related Complications

Ran Harel[1,2], Petros Stylianou[3], Nachshon Knoller[1]

OBJECTIVE: Cervical spine surgery is a common procedure for treatment of wide variety of pathologies. In this paper we report approach-related complication rates experienced by our patients.

METHODS: We retrospectively evaluated data from patients who were treated surgically for cervical pathologies from February 2011 to October 2013. Medical records were collected and evaluated. We compared the anterior cervical approach with the posterior cervical approach for patients operated for all cervical pathologies, and a subanalysis was performed for patients with cervical myelopathy.

RESULTS: The study included 251 patients (192 anterior vs. 59 posterior). The anterior approach patients were younger (not significant), but the indications for surgery varied significantly. Mean number of levels treated was 2.2 approach was associated with significantly lower rates of complication especially infection related complications.

INTRODUCTION

The posterior cervical approach for decompression of the spine has been described as early as the first years of the last century.[1] In recent decades, the addition of lateral mass screws facilitated the fusion of the cervical spine through the posterior approach.[2] The anterior cervical approach was first described on 1958 by Cloward[3] and by Smith and Robinson[4] and was heavily criticized by spine surgeons. This approach gained popularity as a result of improved instrumentation and better technique over the last decades, but the debate for best surgical solution is ongoing.

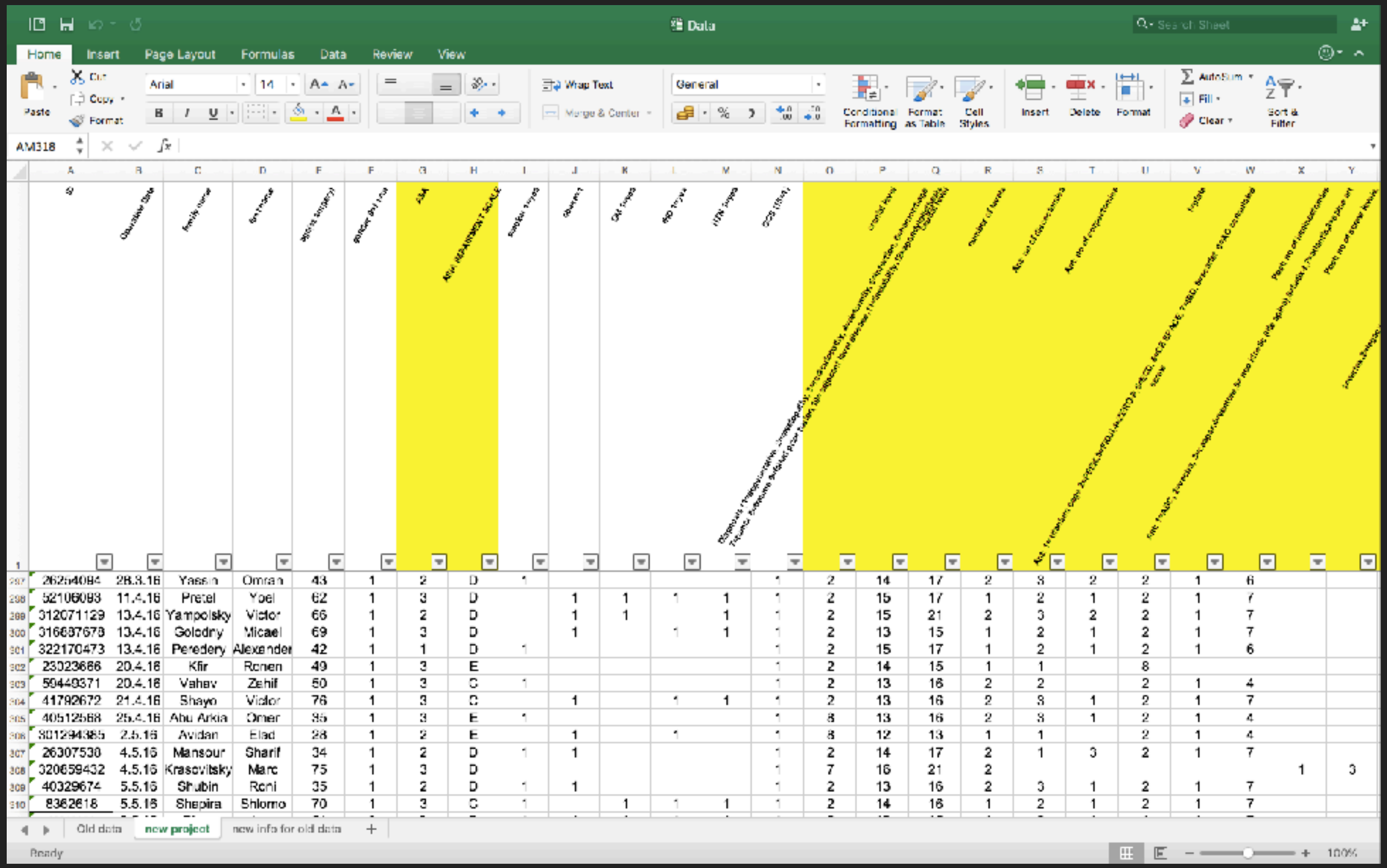
Kristof et al.[5] favored the dorsal approach for multilevel spondylotic myelopathy; however, their retrospective cohort

World Neurosurgery Oct 2016

METHODS

- Retrospective Cohort.
- Participants - Patients operated on at the "Sheba Medical Center" between October 2013 - December 2016.
- Inclusion criteria - All cervical pathologies.

METHODS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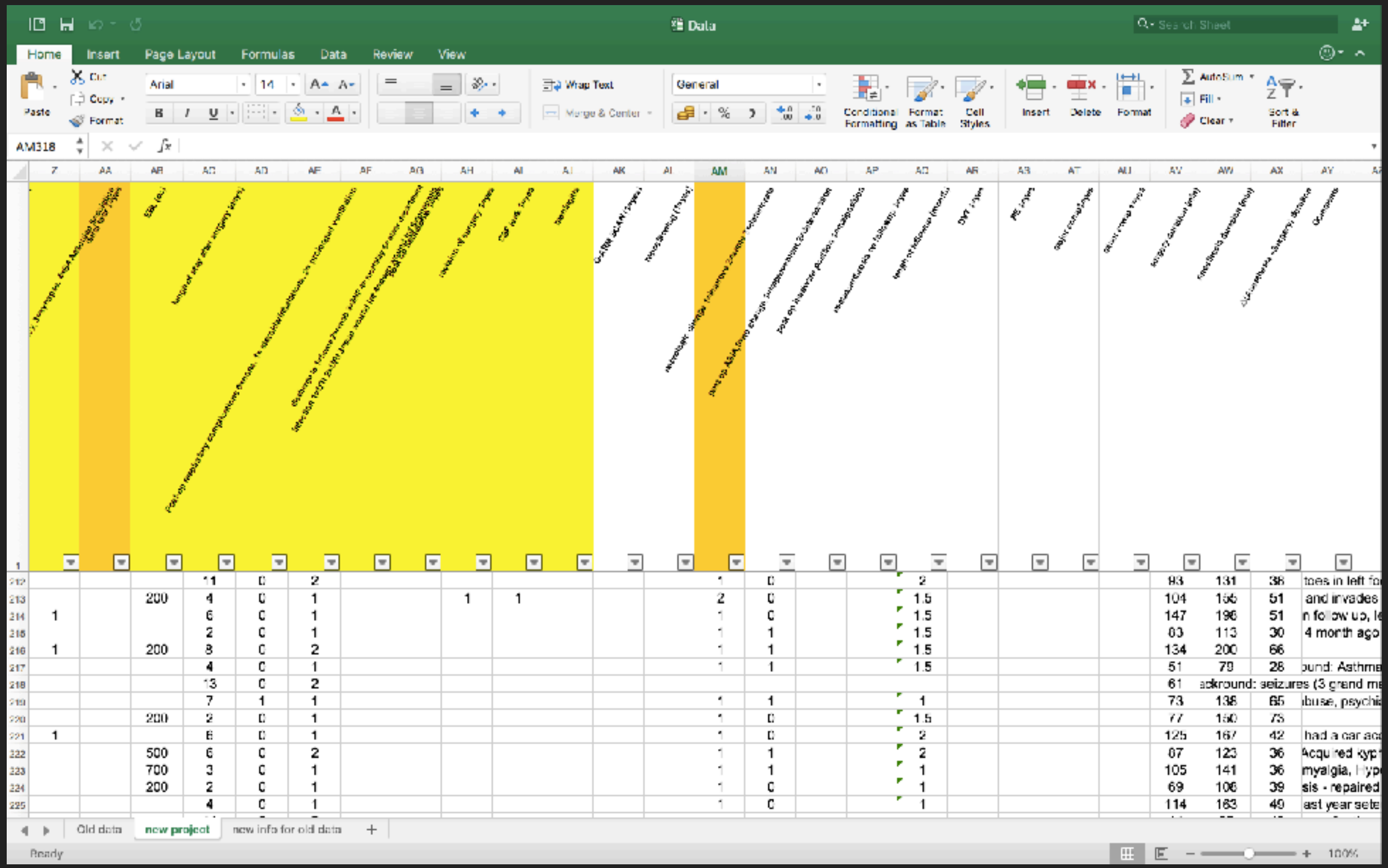
METHODS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LIMITATIONS

- Retrospective Cohort.
- Selection bias - Both senior surgeons favor the anterior approach.

IN THE RECENT FUTURE…

- So far 312 patients
  (in addition to 251 patients - older data)
- 100 more patients (total **663** patients)
- Analyze the results
- Write a paper!

Anterior Cervical Approach for the treatment of Axial or High Thoracic levels

Authors: Ran Harel, MD[1,2]; Maya Nulman[2]; Nachshon Knoller, MD[1]
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Introduction

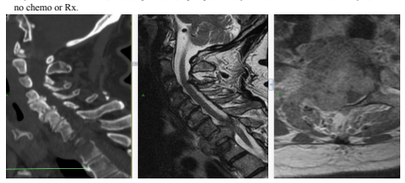
Application of the anterior sub-axial cervical approach to the axial spine or the thoracic spine has been previously described. Evaluation methods to determine the feasibility of these approach were also described but we did not find these methods useful for all our patients. We describe our experience expanding the boundaries of anterior cervical approach utilizing a novel algorithm for approach selection.

Materials and Methods

A retrospective analysis of patients' files and imaging data of all anterior cervical approach to treat pathologies above C2-3 disc space or below C7-D1 disc space. The decision to proceed with standard approach was based on CT or MRI scans and the pre-operative range cervical range of motion. Post-operative course and surgical complications will be discussed.

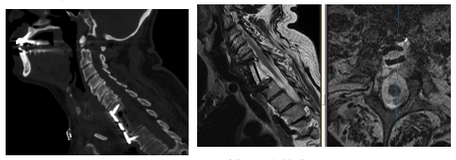
Case Exemple 1:

69y/o male, PMH: HTN, IHD, s/p CABG, s/p nephrectomy d/t clear cell renal cancer 10y/a, en-block resection, no chemo or Rx.



Anterior Cervical approach
D1-D2 corpectomy and C7-D3 fusion
PEEK cage

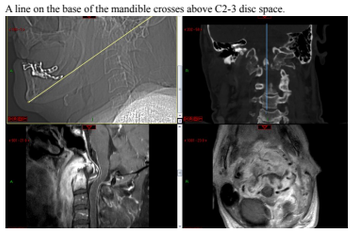
Post surgical radiosurgery treatment:



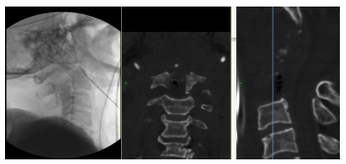
2 year follow-up: Stable disease

Case Exemple 2:

65 y/o male, PMH: DM, s/p toe amputation d/t diabetic foot, HTN, Low compliance
c/o soar throat for 3w, fever, swallowing difficulty, Admitted to internal medicine
Diagnosed with Septic shock, Blood cultures: STREPTOCOCCUS AGALACTIAE
Imaging: Retropharingeal abscess, C1-C2 osteomyelitis causing dens fracture,
C1-2 dislocation with lateral listhesis, epidural abscess dorsal to dens and C2 body, cord compression.
A line on the base of the mandible crosses above C2-3 disc space.



Anterior Cervical Approach, C2 & dense corpectomy, Traction with halo ring



4 days after primary surgery traction converted to halo-vest
40 days post primary surgery: post approach, occipito-cervical fusion with O-arm navigation
IV antibiotics for 3 m; PO antibiotics for 1y; Normalized CRP;
Transferred to rehabilitation after 2m
Rehab: walks with cane, discharge home 3m after admission to rehabilitation,
One year follow-up: No signs of infection, Stable fusion, ambulatory, slight myelopathic signs

Results

During a two year period 13 patients had undergone anterior cervical approach to the axial spine (3 patients) or the thoracic spine (10 patients). Average age was 53 (range: 11-77), 62% were male. Ten patients were treated for tumor resection, one for trauma, one for myelopathy and the last for infective osteomyelitis with epidural abscess. Three patients were previously operated in another hospital via the posterior approach with remaining compressive mass necessitating anterior decompression. Average surgical duration was 96 minutes (range: 48-181minutes) and estimated blood loss (EBL) was 1440cc (range: minimal-7000cc); two renal cell carcinoma metastases and one vertebral hemangioma patient's EBL was over 2500cc. Complications were recorded in 30% of the patients including 1 case of prolonged ventilation, 1 case of CSF leak, 1 patient had post-operative hand weakness, 3 patients suffered temporary hoarseness due to vocal cord paralysis.

Case number	Demographics & Pathology	Surgical Approach	Outcome & Comlications
1	65y/o male, presents with C2 osteomyelitis, dense fracture, antero-lateral C1 listhesis, epidural abscess dorsal to C1-C2 complex and cord compression	High anterior cervical approach, C2 corpectomy and densectomy, halo traction converted to halo fixation and to posterior occipito-cervical stabilization 40 days after first surgery	Discharged to rehabilitation after 62 days, ambulatory, treated with antibiotics, no neurological deficit
2	47y/o female, retropharingeal mass arising from the C1-C2 facet joint, biopsy is positive for Chordoma.	High anterior cervical approach, resection of a tumor mass anterior to the C1-C2 vertebra, coagulation of the insertion to the C1-Dense facet	No complications, no adjuvant therapy, no residual or recurence on followup imaging
3	77y/o female, C2-C4 lytic lesion of unknown pathology, Collapsed C3 with severe cord compression and slight neurological deterioration	High anterior cervical approach, C3-C4 corpectomy, rescetion of lytic lesion of C2 body, reconstruction of C2 with PMMA and stabilizetion with cage and plate C2-C5	Patient improved neurologically and transferred to rehabilitation d/t balance dificulty, histology was consistant with Multiple Myeloma and the patient was treated with chemotherapy. No complications were noted.
4	11y/o female, D3 hemangioma operated by posterior approach at another hospital 6m prior to admission. On addmission the patient is suffering from severe myelopathy, walks with crutches and falls frequently. Severe ventral cord compression is evident.	Low anterior cervical approach, D3 corpectomy and fusion with cage and plate	EBL=2400cc, neurological status improves greadually to normal gait, large dural tear is evident after PLL opening and the only complication encountered is ventral pseudomeningocele with no sequela
5	68y/o male, C7-D1 heriated disc migrating caudaly and compressing the cord against the D1 vertebral body, presented with severe myelopathy	Low anterior cervical approach, D1 corpectomy and fusion with cage and plate	Improved neurologically, post-operative horseness improved spontaneously
6	27y/o male, hyperflexion bicycle injury, C7-D1 burst fractures with fragments compressing the cord, posterior elements fractures, C7 quadriplegia with neurogenic shock	Low anterior cervical approach, C7-D1 corpectomy and fusion with cage and plate; 11 days later posterior instrumentation	Post-operative complicated by pneumonia, transferred to Neurological rehabilitation facility, gradual neurlogical recovery, walks with crutchs at 3m f/u.
7	34y/o male, D1 Aneurysmal Bone Cyst causing pathological fracture with cord compression and myelopathy	Tumor embolization followed by posterior cervico-thoracic decompression and instrumentation. Second stage prefomed 6 weeks later: low anterior cervical approach, D1 corpectomy and fusion with cage and plate.	Improved neurologically, 9 days after surgery CSF leak was noted, the wound was re-sutured and patient treated with CD, No sequela.
8	58y/o male. D2 extradural metastasis of brain atypical chorid meningioma to the vertebral body. Severe cord compression 2m after posterior approach in another hospital with severe myelopathy, non-ambulatory.	Low anterior cervical approach, D2 corpectomy and fusion with cage and plate, treated with spine radiosurgery 40d post-surgery	Improved neurologically, regain walking ability, temporary post operative horseness
9-13	5 patients, age range 43-72y/o, metastases to vertebral bodies ranging C7 to D2, (1-3 levels, all below C7-D1 disc space), pathologies include 2 RCC, 1 TCC, 1 colon Ca, 1 Large B cell lymphoma. All present with either severe myelopathy (2 patients) or radiculopathy causing distal hand weakness (3 patients).	all patients underwent low anterior cervical approach, corpectomies and fusion with cage and anterior plate, none had posterior instrumentation. 2 patients were treated with spine radiosurgery and the rest with fractionated radiation therapy.	4 patients improve neurologically, 1 had worsening of bilateral distal upper extremity weakness attributed to his foraminal tumor compressing the nerves. 2 patients had temporary horseness, 1 patients demonstrated cage subsidance with worsening of the kyphosis treated conservatively with stabilization after 3 months.

Discussion

Treatment of sub-axial pathology by anterior cervical approach is well established as a safe and effective. Approach to the axial or the high thoracic spine is more challenging and harbors approach-related complication. Pre-operative evaluation of patients imaging allows for harnessing the standard approach for treatment of extreme levels with relative safety and efficiency.

Conclusion

Awareness of feasible anterior cervical approach to the axial and high thoracic levels can increase surgical efficacy while reducing the complication rates.

THE 18TH ANNUAL MEETING OF THE ISRAEL SPINE SOCIETY

26-29 April 2017

Wednesday-Saturday
The Royal Beach Hotel
Eilat - Israel.

האיגוד הישראלי לעמוד השידרה
ISRAEL SPINE SOCIETY

FLUOROSCOPY

A fluoroscopy is an **imaging** system which uses X-ray to obtain real-time moving images. It involves high radiation rates to the patient and to the medical staff.

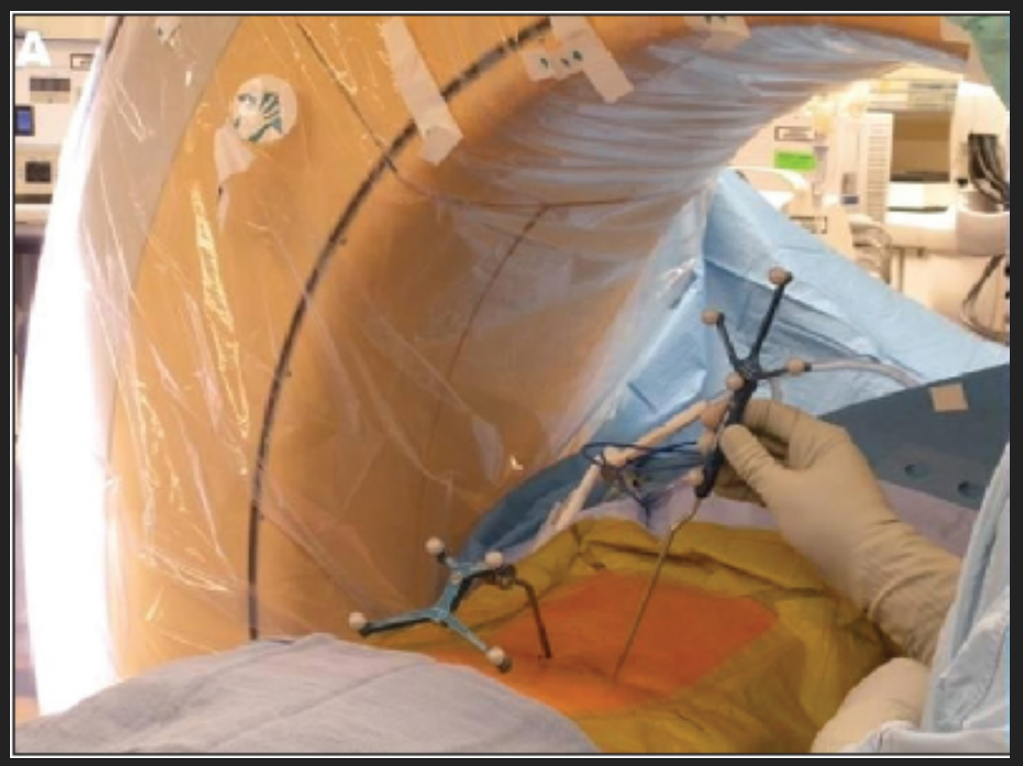
SPINE NAVIGATION SYSTEM

- In order to improve the identification of anatomic structure and the accuracy of pedicle screw placement, the intraoperative computed tomography- (iCT-) guided navigation has been developed.

SPINE NAVIGATION SYSTEM

O-ARM NAVIGATION SYSTEM

- Increases the accuracy of the procedure.
- Reduces morbidity and invasiveness.
- Diminishes the radiation dose to the medical staff.
- Useful in a high variety of pathologies such as spinal decompression or tumor resection.



O-arm navigation in spinal surgery for complex cases. Pescador D. Acta Ortop Mex 2016

O-ARM AND NAVIGATION GUIDED CERVICAL SPINE SURGERY FOR AXIAL FUSION

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AXIAL SPINE FIXATION

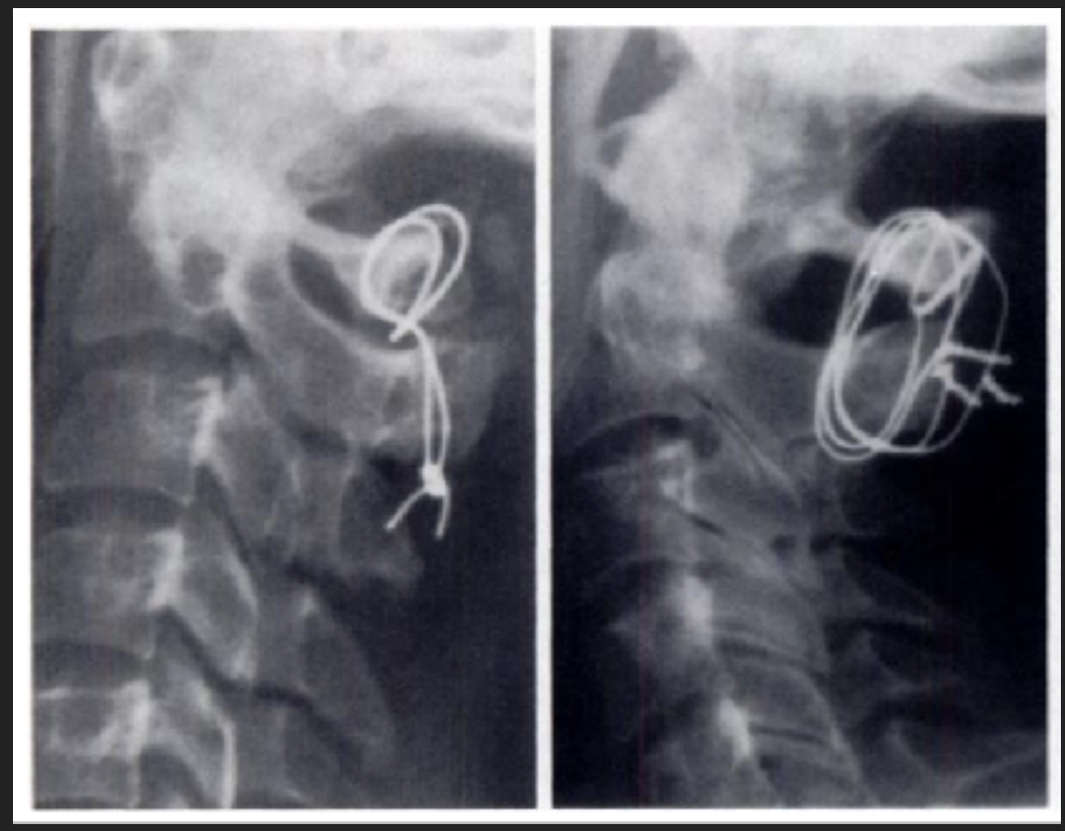
- C1- C2 instability is caused mainly by trauma but also due to degenerative and developmental pathologies.
- Axial spine fixation is a difficult, high risk procedure which can be addressed by several techniques.

AXIAL SPINE FIXATION EVOLUTION

HISTORICAL METHODS - WIRING

- Two of the first methods for axial spine fixation made use of **wiring** and **bone grafts** (eg Gallie and Brooks).
- The problem is that wire fixation resists flexion, however it fails to resist extension and rotation.

Gallie Brooks



Part 1. Principles, Basic Hardware, and Fixation Techniques for the Cervical Spine. Radiographics 1993. MD Richard M. Slone et al

AXIAL SPINE FIXATION EVOLUTION

SCREW FIXATION

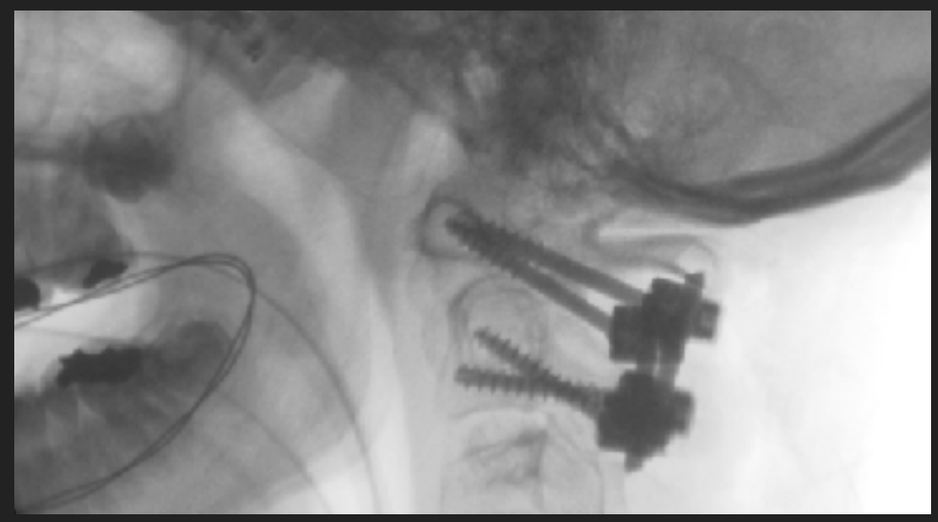
- Screw fixation methods result in **high** fusion rates, however **require** high technical skills due to the risk of injury to the Vertebral Artery, the C1-C2 Venous plexus or other neural structures.
- These methods include:
  - C2-C1 Transarticular screws - Magerl
  - C2 Pedicle screw
  - C2 Pars screw
  - C2 Intralaminar screw
  - C1 Lateral mass screw

- Accuracy and complications of transpedicular C2 screw. Eur Spine J 2010. Muller CA et al
- Placement without the use of spinal navigation. J Neurosurg Spine 2005. Wright NM

AXIAL SPINE FIXATION EVOLUTION

HARMS PROCEDURE

- The Harms procedure includes the insertion of Polyaxial screws into the C1 lateral masses and two Polyaxial screws are inserted into the Pars Interarticularis of C2. Drilling is guided by means of a fluoroscopy as well as anatomical landmarks.
- Studies have demonstrated that the Harms procedure requires **less** time in the OR, involves **less** intra-operative blood loss, **less** X-ray exposure and **less** malpositioning of the screws.



- Posterior C1-C2 fusion with polyaxial screw and rod fixation. Spine 2001 Harms J, Melcher RP.
- Harms technique of C1-C2 fixation with polyaxial screws and rods. Acta Chir Orthop Traumatol Cech 2005. Stulík J et al

O-ARM NAVIGATION SYSTEM

THEORETICAL BASIS

- The O-arm navigation system offers high resolution images (both in 2D and 3D), facilitates the **accuracy** of pedicle screw insertion and **reduces** the risk of operational revision.
- However, Pedicle Screw perforation **cannot be** completely avoided.

- Clinical outcomes following spinal fusion using an intraoperative computed tomographic 3D imaging system. JNS 2017. Xiao R et al.
- Intraoperative, full-rotation, three-dimensional image (O-arm)–based navigation system for cervical pedicle screw insertion. JNS 2011. Ishikawa Y et al.

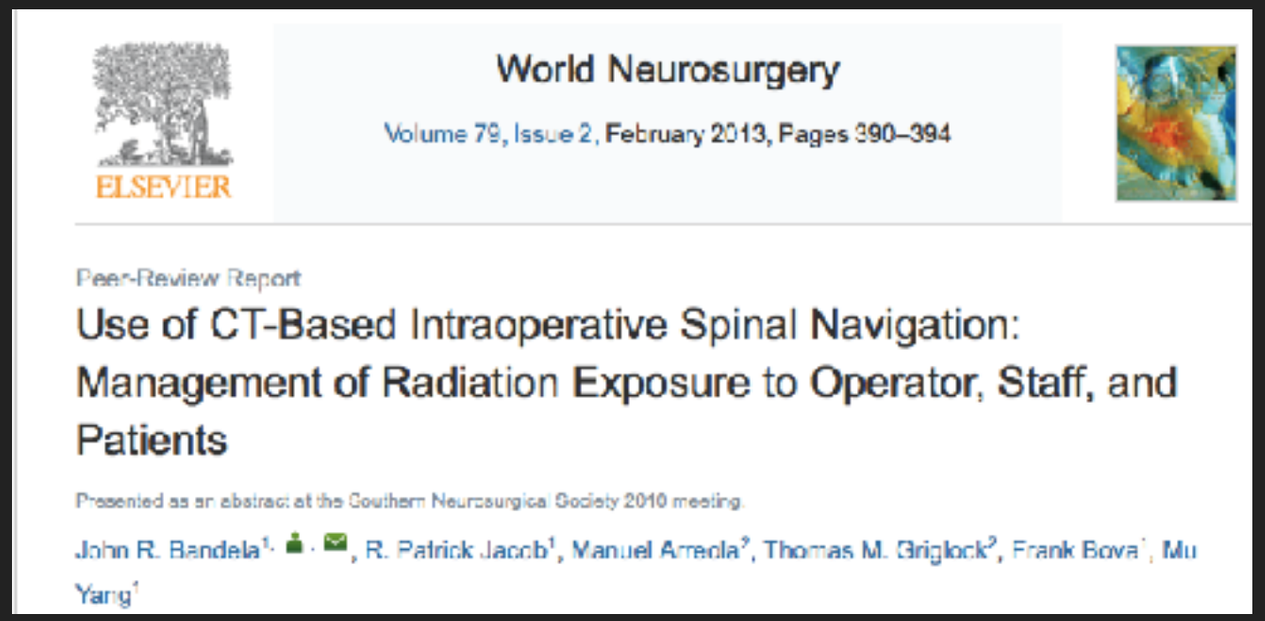
Dr. Harel and Dr. Etingold operating using the O-arm navigation system.

O-ARM NAVIGATION SYSTEM

THEORETICAL BASIS

- The O-arm navigation system was proven to have **lowered radiation** rates absorbed by the **medical staff.**
- Even in **very low** radiation rates to the medical staff - the quality of the images obtained **remains consistent**.

Low Dose Radiation 3D Intraoperative Imaging - How Low Can We Go? An O-Arm ®, CT Scan, Cadaveric Study. Spine 2017. Sarwahi V et al.



METHODS

- Retrospective Cohort - comparing neuronavigation group to no neuronavigation control group.
- Participants - Patients operated on at the “Sheba Medical Center” between July 2011 - December 2016.
- Inclusion criteria - Posterior approach fixation surgery on C1, C2 or both. These operations were performed to treat trauma, degenerative or instability pathologies.

RESULTS

SUBANLYSIS: C1-C2 FIXATION

		O-arm Navigation System	Free hand/ Fluoroscopy	P-value
Pateints		6	8	
Age		36.8	47.25	0.41
Gender (%Male)		50%	50%	
Risk Factors	**Smoking**	0	0	
	Diabetes Mellitus	0	0	
	IHD	0	0	
	HTN	0	3 (37%)	
Pathologies	**Degenerative**	0	0	
	Trauma	4 (67%)	(50%) 4	
	Instability	2 (33%)	(50%) 4	

RESULTS

SUBANLYSIS: C1-C2 FIXATION

	O-arm Navigation System	Free hand/ Fluoroscopy	P-value
EBL (cc)	433.3	462.5	0.89
Surgery duration (min)	120.2	105.6	0.32
△[Anesthesia - Surgery duration] (min)	93.4	70.6	0.13
Length of stay (days)	3	4.1	0.27
Length of follow-up (months)	1.75	2.5	0.53

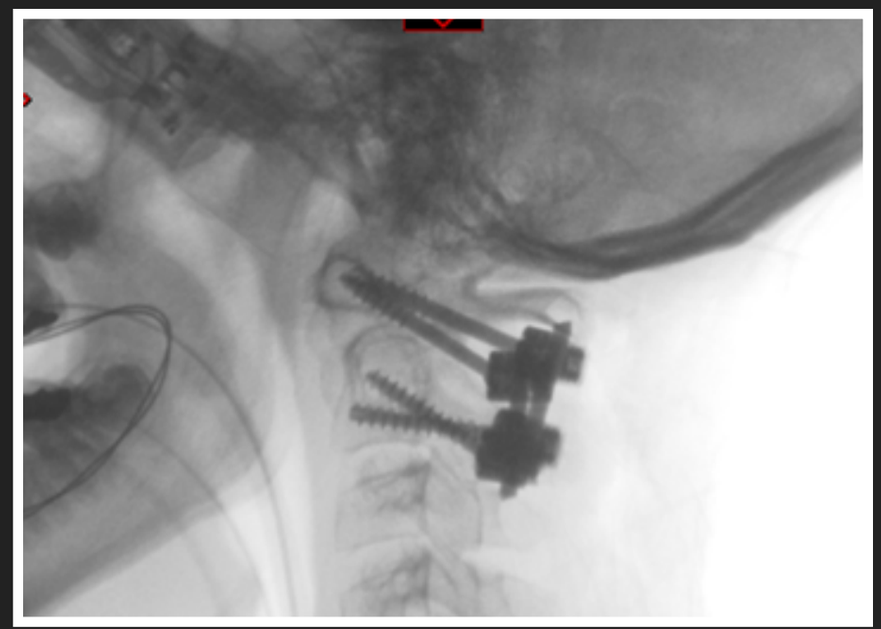
RESULTS

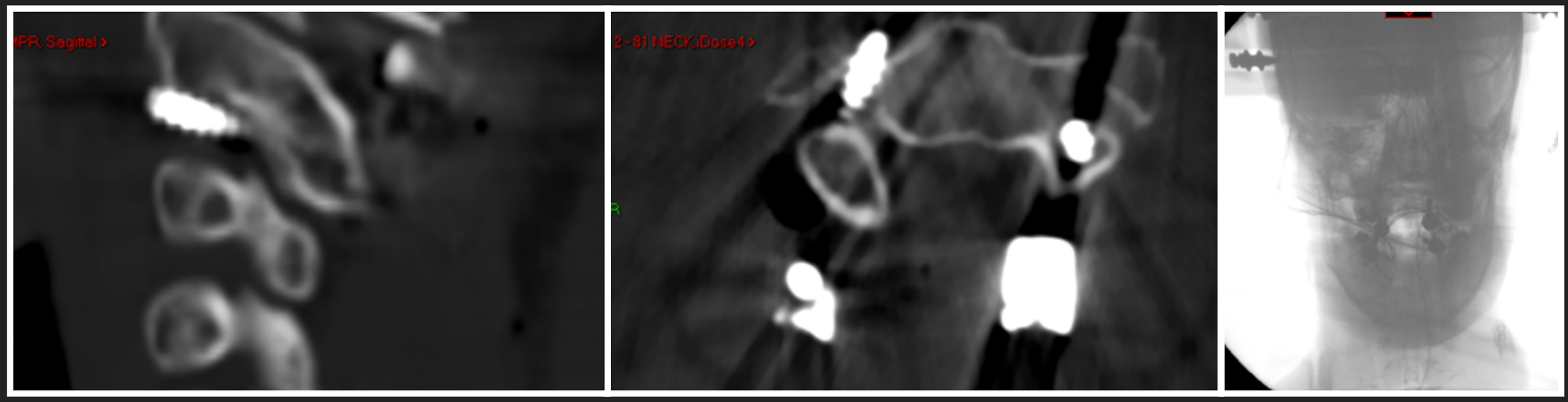
SUBANLYSIS: C1-C2 FIXATION

		O-arm Navigation System	Free hand/ Fluoroscopy	P-value
Repositioning of screws intraoperatively		**1 (17%)**	**0**	
Malpositioning of screws		**0**	**1 (13%)**	
Revision of surgery		0	0	
Neurologic change	**Improve** **Stable** **Deteriorate**	6 (100%) 0 0	4 (50%) 4 (50%) 0	
Discharge destination	**Home** **Rehabilitation**	6 (100%) 0	6 (75%) 2 (25%)	
Total complications		**0**	**1 (13%)**	

RESULTS

- These are the post operation CT images of the patient from the control group (13%) who underwent the Harms procedure.
- The images display the **malpositioning** of the screw which was not revised.
- It could have been prevented had we used the **O-arm navigation system**.





LIMITATIONS

- Retrospective Cohort.
- **Low** number of participants.
- **Higher** Risk factors for the patients who underwent the procedure by means of the O-arm navigation system.

CONCLUSIONS

- Axial cervical spine instrumentation is **challenging** and exposes the surgical team to radiation.
- Utilization of imaging and navigation guidance **reduces** the risks for both patients and surgeons.
- In addition, navigation may **increase** screw placement **accuracy**.


YAMAHA

THANK YOU!