Manual vs. Automated Measurement of Syrinx Volume

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Background

- Syringomyelia occurs when a fluid-filled cyst, called a syrinx, develops in the spinal cord.
- Lesions that block the flow of cerebral spinal fluid can cause syrinx development which damages the spinal cord.

Cases and Prevalence

- Syringomyelia often develops in association with Chiari I malformations, tumors, and spinal cord injuries.
- Syringomyelia has a prevalence of approximately 8.4 / 100,000 people.
- Symptoms prompt MRI scans & syringomyelia diagnosis.

Symptoms and Pathophysiology

- Syringes compress central nervous system (CNS) neurons.
- Cervical Syringomyelia causes upper extremity weakness, loss of sensation, and chronic pain.
- 5 % of paraplegia is due to syringomyelia.

Surgical Treatment

- Decompression surgery opens the cerebrospinal fluid pathways, reduces the syrinx size, arrests the neurological progression, and may reduce the symptoms of syringomyelia.
- Syrinx volume decreases after successful surgery.

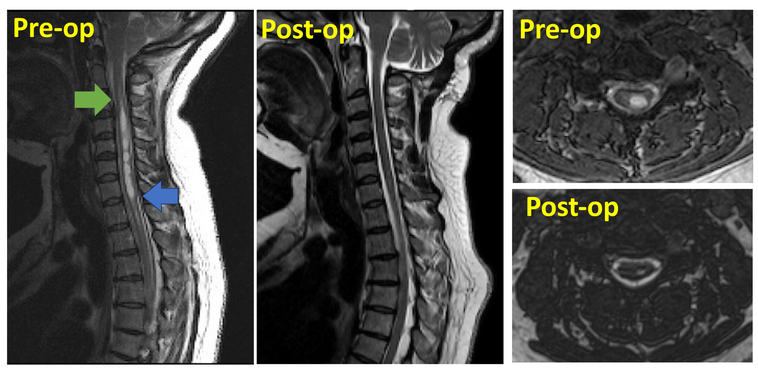

Fig. 1: MRI scans before and after treatment by decompression surgery. Sagittal (left) & axial MRI images (C4 segment) (right) of the cervical spine.

Manual Method: Cavalieri Principle (CAV)

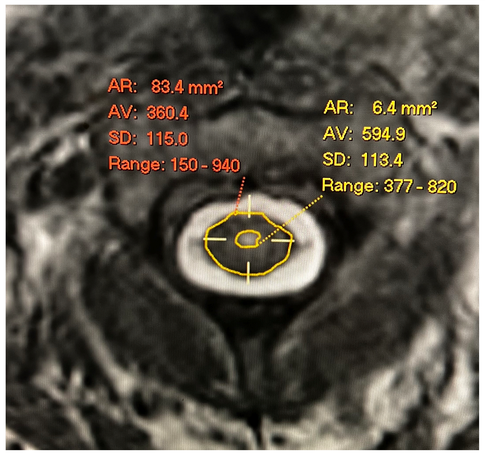

Fig. 2: T2-weighted axial scan of a spinal cord with syrinx was manually measured.

- T2-weighted MRI scans were used.
- Volumes were calculated by summing the individual volumes of all the 1mm thick slices taken through the syrinx.
- We compared syrinx volume before & after surgery in all patients.
- We used CAV as the gold standard method of syrinx volume analysis when comparing it to other syrinx volumetric analysis programs.

Automated Methods: SCAT and 3Dqi

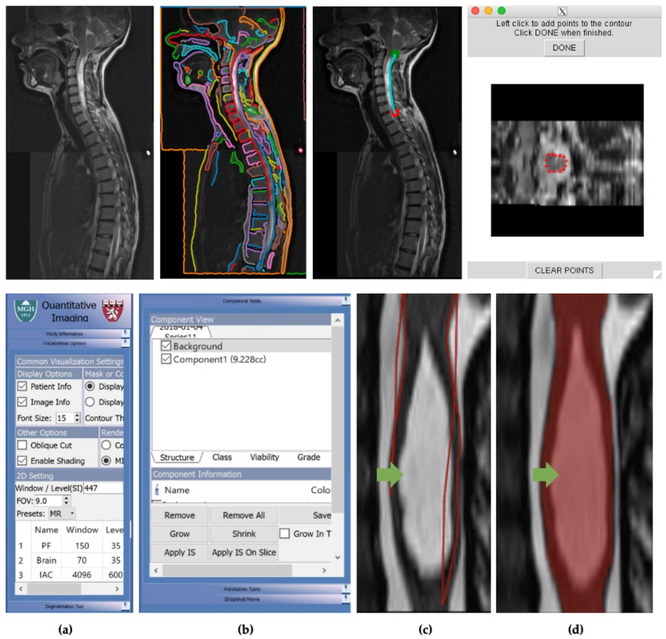

Fig. 3: SCAT edge detection (top) and 3Dqi (bottom) were used to measure syrinx volume on T2-weighted axial MRI images.

- To measure syrinx volume, we used the edge detection software Spinal Cord Analysis Tool (SCAT) (NINDS MRI Facility) to analyze stitched spinal cord MRI scans.
- We also used the volumetric analysis tool 3Dqi (Massachusetts General Hospital) to measure syrinx volumes.

Results

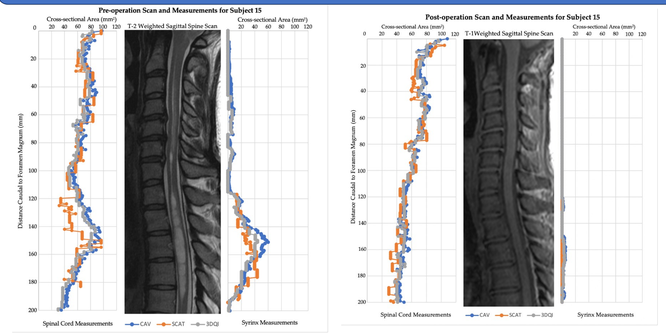

Fig. 4: Comparison of preoperative (left) & postoperative (right) spinal cord & syrinx measurements using CAV, SCAT, and 3Dqi.

- All methods detected a significant reduction in syrinx volume postoperatively (CAV: p = 0.00037, SCAT: p = 0.0014, 3Dqi: p = 0.00767).
- Preop and postop syrinx volumes measured by CAV and SCAT were not significantly different (p = 0.891, p = 0.82)
- Preop and postop syrinx volumes measured by CAV and 3Dqi were significantly different (p = 0.018, p = 0.032)

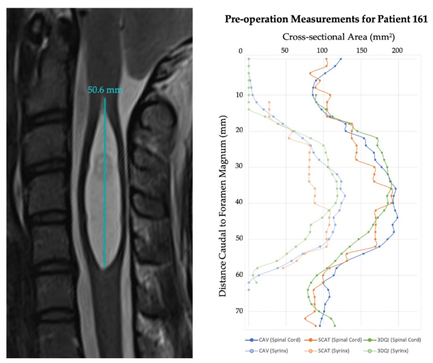

Fig. 5: Comparison of Preop spinal cord and syrinx volumes calculated by CAV, SCAT, and 3Dqi.

- Preop and postop spinal cord volumes measured by CAV and SCAT were significantly different (p = 0.008, p = 0.0001).
- Preop and postop spinal cord volumes measured by CAV and 3Dqi were not significantly different (p = 0.205, p = 0.124)

Conclusions

- Semiautomated syrinx measurement is faster than the manual method and reliably detects surgically-related reduction in syrinx volume.

References:
1. Heiss et. Al. Neurosurgery 2018 Mar 30. Origin of Syrinx Fluid in Syringomyelia: A Physiological Study
2. Liu & Nair et. Al. Ann Neurol. 2015 Sep 1. In-Vivo Imaging of Spinal Cord Atrophy in Neuroinflammatory Diseases