Ultrasound (US) Assessment of Cervical Spinal Canal Diameter for Efficacy of Discectomy

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Abstract

Background: Degenerative cervical disc disease is a common condition that people develop symptoms gradually, they can be easily grouped into axial neck pain, radiculopathy, and myelopathy. Surgery is performed to decompress the spinal cord. While imaging are used in the perioperative spinal cord decompression including computed tomography (CT) scan, magnetic resonance imaging (MRI) and ultrasound (US) usage is relatively new. US is a simple, safe, rapid, noninvasive, and inexpensive modality that constitutes a potential alternative when other modalities are not suitable or unavailable.

Purpose: The purpose of this study was to report the ability of ultrasound to assess the cervical spinal canal diameter for efficacy of Discectomy.
Patient sample: 30 patients will be enrolled in this study. All patients complained of cervical spinal canal stenosis symptoms.

Outcome Measures: Patients were assessed pre-operative & postoperative clinically & by US.

Methods: It consists of a prospectively collected consecutive series of 30 patients with cervical disc disease who met inclusion criteria between July 2018 and April 2019 with last follow up May 2020. They were selected for Anterior cervical decompression Discectomy then measuring the canal diameter by US done in Helmya Hospital, Cairo, Egypt. The study include 15 males and 15 females with mean age 38 years.

Results: There was statistically significant relation between Preoperative US & MRI (P<0.01), There was statistically significant variation between pre-operative & postoperative US (P<0.05), VAS significantly improved postoperative (P<0.05) and fusion rate 123 of 30 cases (40%) by 6th month and in 25 of 30 cases (83.33%) by one year.

Conclusion: US has wide availability and low cost which makes it easy and cheap to use.

KEYWORDS: Ultrasound / Cervical canal / Discectomy /ACDF.

Introduction Compression of the cervical spinal cord by cervical disc can lead to progressive clinical symptoms, such as neck pain, numbness, and limb paralysis below the Compression site. The posterior arch of the vertebral bone (lamina) also can in some cases compress the spinal cord, necessitating removal of the offending section of bone. Surgery is the usual treatment for all types of spinal compression, as pressure on pinched nerves must be relieved to facilitate recovery of spinal cord function (1).

Prior to surgical interventions, surgeons and radiologists commonly employed X-rays, computed tomography (CT) scans, and magnetic resonance imaging (MRI) to guide therapeutic decisions. The introduction of high-resolution, real-time ultrasound (US) scanners in the 1980s allowed for the visualisation of physiological motion as it happens, which made its utility in the intra-operative setting possible (2).
Since then, US has been used to image the spine in order to assess the effectiveness of decompression and determine the configuration of the spinal cord (3). Unlike CT scans or X-rays, US does not require the use of potentially dangerous ionizing radiation, and it can be used to generate real-time images unlike MRI (4).

Some identified that imaging strategies should be flexible enough to be used in the pre-, intra-, and post-operative care of patient. Therefore US needs to meet these criteria in order to establish its benefit over other imaging modalities. US is a simple, safe, rapid, non-invasive, and inexpensive modality that constitutes a potential alternative when other modalities are not suitable or unavailable (5).

Non-operative treatment is indicated in patients with mild myelopathy (i.e., mild hyper-reflexia without Functional impairments), or in whom medical comorbidities make the risk of surgery too great. Asymptomatic patients with evidence of cervical cord compression on MRI are also candidates for non-operative management (6).

For these patients, immobilisation and isometric exercises may reduce the neural irritation and provide some relief from myelopathy symptoms. Non-steroidal anti-inflammatory medications may provide symptomatic relief early in the disease course as well. Epidural steroids and cervical traction do not reduce the symptoms of myelopathy and may present increased risk in an already compromised spinal canal, in contrast to the dramatic relief seen in some patients with radiculopathy (6).

Indications for surgery include persistent or recurrent arm pain with or without weakness, not responsive to 3 months of non-operative treatment. A progressive neurological deficit with confirmatory imaging studies consistent with the clinical picture is an absolute operative indication (7).

The results of operative intervention for axial neck pain are inferior to the results for radiculopathy; these factors that should be considered include workers compensations cases, mental health issues such as depression and substance abuse. These factors have a negative impact on treatment, with surgical results for these patients lagging behind results of other patients (8).
Patients and Methods
This study was done using standard methodology outlined in the Cochrane Handbook and reported the findings in accordance with the statement guidelines.
After Ethical committee approval, all patients signed an informed and detailed consent preoperatively containing the procedure and all possible complications.
A total number of thirty consecutive patients diagnosed with either cervical radiculopathy or cervical spondylotic myelopathy undergoing anterior cervical interbody disectomy and fusion in Al Helmya military hospital between July 2018 and April 2019 with last follow up May 2020. They had pre-operative US and MRI imaging studies and post-operative US follow up images. The average follow up period was 18 months ranging between 12-20 months.

Table : Baseline demographic of the patient cohort were as follows.

<table>
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<tr>
<th>Case N</th>
<th>Age</th>
<th>Sex</th>
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<th>VAS UL preop</th>
<th>NDI preop</th>
<th>Duration (ms)</th>
<th>Side (ULP)</th>
<th>Level (C)</th>
<th>Op. Time (min)</th>
<th>Hosp. Stay (d)</th>
<th>BI Loss (ml)</th>
<th>VAS neck post</th>
<th>VAS UL post</th>
<th>NDI postop.</th>
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Radiological Evaluation: We used x-ray, MRI and a mobile ultrasound machine. With transducer probe which has a 20 mm diameter and offers a 4.4 to 10 MHz frequency range, to be the most compatible for our specification. It gives a depth view of 20 cm optimum to measure cervical spinal canal diameter.

Table: Radiological Evaluation.

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operative time: The mean operative time was 121.4±23.22 (range 100–180 min).

Pre-operative radiological assessment:
1) X rays: AP and lateral radiographs of the cervical spine
2) MRI: MRI Scan of cervical spine was performed for all patients as it provides a detailed overview. Ligamentous injury, Disc rupture, Spinal cord injury, Epidural haematoma, and Medicolegal.
3) US: for assessment for cervical spine canal diameter acting as a reference for post-operative assessment for cervical canal diameter.

US Technique: The ultrasound probe should then be placed within the saline bath or hydrobasic gel substance as transducer media to obtain images. Patient position: (Posterior acoustic window) patient lying in prone decubitus or sitting, with the neck in anterior flexion to reach Posterior column & cervical spinal canal.

Landmarks: Superficial landmarks can be used to guide the ultrasound exploration. The superior aspect of the thyroid cartilage corresponds to C4, the inferior tip of the mastoid process is situated just superior and laterally to the transverses processes of C1 and the spinous process of C7 (vertebra prominence) can be easily recognized at palpation.

We examine in longitudinal planes (sagital), mark the level then the transverse (axial) planes to measure canal diameter in millimeters from Posterior to anterior.
Fig. Position and US on a patient with examination of cervical spine.

Fig. Pre-operative US: level C5/6, disc Lt side Spinal canal diameter: 11.6 mm.

**Preoperative protocol:** a) History taking  
b) Examination Neck, Upper Limb, Lower Limb Gait, Functional Assessment (Sensory motor & reflexes)

**Indications for Surgery**
1) A progressive neurological deficit with confirmatory imaging studies consistent with the clinical picture is an absolute operative indication

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2) persistent or recurrent arm pain with or without weakness, not responsive to 3 months of non operative treatment.

**Inclusion criteria:** Prospective study, patients of all ages with cervical spinal canal stenosis caused by disc compression after failure of conservative management at least 3 months, procedure: All patients will do ultrasound pre- & post-operatively for assessment of cervical spine canal diameter, Outcome measures: Greater than or equal to one pre-specified quantifiable Outcome measure (They included measures of clinical and radiological outcomes) and level of evidence: Provides level IV of evidence.

**Exclusion criteria:** Revision cases (Previous surgery at the index level), systemic or local infection cases, refuse surgery or follow up, cases with no clinical data, active rheumatoid arthritis and medically unfit for anesthesia.

**Operative Technique:**

**Positioning:** Patient was positioned in the supine position, with the arms tucked to the sides. Positioning of the neck and head during intubation and operation is of paramount importance in any cervical decompression surgery. In case of severe compression; awake nasotracheal intubation or fiberoptic intubation was performed. A small rolled towel was then placed between the scapulae to extend the neck slightly. Pre-operative planning landmarks done on. The neck was then prepped and draped in the usual fashion.

**Surgical approach:** Image initially was taken using the fluoroscopy for determination of the level of the incision. Smith-Robinson anterolateral approach was done with transverse incision, the approach was from the left side of the neck. The vertebral bodies and disc can then be identified by palpation in the midline. A subperiosteal dissection of the prevertebral fascia and longus colli muscles using an elevator should then be performed. Once the longus colli muscles had been elevated, the hand-held Cloward retractors may be placed directly underneath the longus colli muscles. At this point, the
fluoroscopy was used to identify the level with a spinal needle in a particular disc space.

**Anterior Cervical Discectomy:** With exposure of the disc spaces complete, anterior discectomies were then performed one by one. The anterior osteophytes was removed using a rongeur then a rectangular incision was made through the anterior longitudinal ligament and outer annulus using #15 scalpel blade on a long handle. Through this opening, the intervertebral disc, including the degenerated nucleus pulposus was removed. After a significant amount of disc material was removed, Kasper spreader was placed; the remainder of the disc and the cartilage end plates were then removed with curettes to allow complete removal of all disc material.

All cartilage should be removed, but the bony end plates should not be resected. The posterior longitudinal ligament was visualized, if a tear was seen in the ligament, then resection of the ligament performed with a 1-mm Kerrison rongeur. After complete resection, a micro nerve hook was used to probe the posterior border of the superior and inferior vertebrae for any sequestered disc fragments. Removal of the posterior osteophytes was done.

Repeating this maneuver for discectomy of the other levels was done then the prepared disc spaces were then distracted after holes were made in the bony end plates superiorly and inferiorly using curettes. The distraction was accomplished manually by the the assistant. The spaces were then measured by the trial fits. The appropriate cages PEEK were filled with autograft. A lateral view of the cervical spine was obtained using the fluoroscopy in order to confirm adequate placement of each cage. Suction drain size 12 was applied then wound was closed in layers.

**Postoperative care:** The patients were placed in a rigid Philadelphia collar for 2 months. I.V antibiotic (Ceftriaxone 1gm) every 12 hours for 3 days post-operative and assessment of analgesic requirement. Post-operative radiograph was done on the first post-operative day in AP and lateral views. Post-operative posterior window US for measuring cervical canal diameter. The patients were allowed to be up out of bed
later on the day of surgery or the next morning. The drain was removed on the first Post-operative day.

**Hospital Stay:** Patients were discharged from the hospital 2 to 3 days after the operative procedure.

**Follow up:** Clinical Follow up: Pain and disability were assessed by NDI and VAS on 1, 3, 6, 9 and 12 month intervals. Radiological: Serial postoperative radiographs on 1, 3, 6, 9 and 12 month intervals and CT was performed after 6 and 12 months intervals to confirm fusion rate (demonstrated trabecular bone bridging). US can be done just immediately post-operatively & in regular intervals 1, 3, 6, 9 and 12 month to confirm canal diameter.

**Results:** Statistical analyses were performed using SPSS 16.0 statistical software (SPSS Inc., Chicago, IL, USA). The Radiological and clinical values were expressed as means ± standard deviation. A *P*-value <0.05 was considered statistically significant and that *P*<0.001 was considered highly significant.

**Clinical outcome:** the results of pre-operative mean of pain with 1,3,6,12 months Post-operative found *P*-values statistically significant (<0.05), It indicates strong evidence against the null hypothesis, as there is less than a 5% probability the null is correct (and the results are random).

![Mean pain assessment score](chart)

**Chart:** Mean Pain assessment scores statistics.

**Radiological outcomes:**

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1. **Fusion**: Radiological assessment of fusion was carried out at 6 months and one year. Fusion was considered successful if plain radiograph demonstrated trabecular bone bridging. Fusion was present in 12 of 30 cases (40%) by 6th month and in 25 of 30 cases (83.33%) by one year.

![Chart: Fusion rate statistics.](image)

2. **Assessing cervical spinal canal diameter by US in mm**: That the mean of result value of pre-operative US almost the same like (≈) the mean of result value of pre-operative MRI. That the standard deviation value of Post-operative US detect the change of the diameter post-operatively. On comparison the results of pre-operative US with 1, 3, 6, 12 month Post-operative we found highly significant difference data result (P<0.05). It means that the US can be used as diagnostics and follow up tool.
Chart: Area Chart showing significant difference between pre-operative (green) & post-operative (pink) US values (more than 1 square).

Chart: Comparison the results of pre-operative US with 1, 3, 6, 12 month post-operative.
Correlation of US with clinical and Radiological finding:
On measuring the Correlation of US with clinical finding we used NDI as an indicators to patient comprehensive clinical state and used correlation coefficient as measure of dependence between two subjects to establish a line of best fit through a dataset of two variables and indicate how far away the actual dataset is from the expected values. We find a significant correlation of US with clinical finding (NDI) on measuring correlation coefficient that give assume values in the range from $>0$ to $+1$ can indicate a predictive relationship that can be exploited in practice. On contrast to Radiological finding (bony fusion in x-ray) we find no significant correlation with US values that give assume values in the range from $<0$ to $-1$, that relationship cannot be used in practice.

![Correlation US to Clinical & Radiological](chart)

Chart: Correlation of US with clinical and radiological finding. “According to the chart pre-operative US measure values in mm (blue) increased significantly to post-operative US measure values in mm (yellow) with correlation in significant decrease in neck disability index from pre-operative (red line) to post-operative (green line).”

Post-operative complications:
Four cases (13.3%) complained of hoarseness of voice, which resolved spontaneously by 1 week. Five cases (16.6%) of dysphagia were observed all were resolved within 1-2 week. One patient (3.3%) had a transient unilateral Post-operative weakness in shoulder abduction that completely recovered by three weeks and one case reported quadriplegia return to reperfusion injury. Two case (6.6%) developed superficial wound infection both were due to non-
compliance with post-operative antibiotic administration. Both cases improved with intravenous antibiotics.

**Discussion**

Degenerative disc disease may be due to compression of a cervical nerve root or the spinal cord results in neck pain, radiculopathy and cervical myelopathy. Diagnosis is achieved by clinical assessment, plane radiography, MRI and CT scan in selected cases. Surgical management depends on neural decompression followed by reconstruction of the motion segment. Anterior cervical Discectomy and fusion has been widely accepted as a successful and reliable surgical treatment for cervical disc disease(8).

This study was aiming to compare the results of cervical canal diameter post discectomy using US with one year follow up. The results of this study were recorded, presented in tables and charts and statistically analyzed. There were significant differences between the preoperative and postoperative US.

Comparing the pre- and postoperative VAS for both neck pain and brachialgia were statistically significant. High fusion rates with good clinical outcomes can be achieved with few complications using this technique. Proper patient selection continues to be the most important factor in good clinical outcome with this procedure as well as others.

The US with its benefits as rapid diagnostic, real time, dynamic, minimally affected by metal artifact and interact with the patient. So, we can use it as a tool for assessing structure morphology of cervical canal pre- & post-operatively with its benefit of guiding real time interventional procedures (usage intraoperative).

Other technical benefits of US in comparison to its competitor MRI being a portable machine easily used everywhere, relatively inexpensive and lack of hazardous radiation in comparison to CT(9). Conversely, US disadvantages technically has limited field of view within a certain body area to the probe ratio, limited penetration to large body areas (fatty persons) it need a high power high resolution US, operator dependent it is the most significant point as the learning curve is very slow with lack of educational infrastructures and variable
quality of machine used according to its power, frequency probe selection and price(10). There are currently five active trials comparing the intra-operative US to MRI & CT in assessing cervical canal diameter.

So the use of US for assessing cervical canal diameter provides a reliable assessment of cervical canal stenosis and in ACDF with promising method, easy, simple and with no known complications. This study reports that there is significant increase cervical canal diameter at 1 year follow up. In combination with patient reported improvements in pain outcomes, functional outcomes and a minimal rate of dysphagia. Moreover, its wide availability and low cost makes US easy and cheap to use.

References:


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Case 1: Male patient, 42 year presented with right shoulder pain, tingling & numbness of the fingers, progressive 1ys ago, Radicular pain (VAS) 8. Has some limitation in RoM due to pain, weakness in elbow flexion and hand grip grade 4, C6,7 right altered sensation. Imaging revealed C6/ C7 right side prolapsed cervical disc with SCD about 12.8 mm.

Operation was done in of 20Th July 2018. Patient was operated with ACDF. Operative time was 100 min.

Post-operative US 2nd post-operative day 22Th July 2018: Level C6/7, no remnant disc compressing the cord or nerve root spinal canal diameter: 13.8 mm, 1 m postoperative US 13.9 mm, 3m postoperative US 14.1mm, 6m postoperative US14.3mm &12 m postoperative US 14.5mm last follow up at 2 Sept. 2019.

Vas of Neck pain improved from 8 to 2 (3 months follow up) and maintained to 2 (1year follow up), Vas of upper limb pain from 8 to 1 (3 months follow up) and maintained to 1 (1year follow up), NDI from 24 to 15 (3 months follow up) and to 4 (1year follow up).
Fig. 67: Pre-operative x-ray.

Fig. Pre-operative ultrasound level C6/7, disc Rt side, Spinal canal diameter: 12.8 mm.

Fig. MRI Found disc level C6/7 compressing the cord, Enchroaching over neural exit of the RT roots, Spinal canal diameter: 12.28 mm.
Fig. Post-operative x-ray C6/7 discectomy & standalone peek cage confirm its position.
Fig. Post-operative ultrasound: level C6/7, no remnant disc compressing the cord or nerve root. Spinal canal diameter: 13.8 mm.

Fig. Post-operative follow-up 1 month ultrasound: Spinal canal diameter: 13.9 mm.
Fig. 73: Post-operative follow up 3 m ultrasound: Spinal canal diameter: 14.1 mm.

Fig. Post-operative follow up 6 m ultrasound: Spinal canal diameter: 14.3 mm.
Fig. Post-operative follow up 12 m ultrasound: Spinal canal diameter: 14.5 m