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TECHNICAL NOTE

Alexis retractor efficacy in transthoracic thoracoscopically assisted discectomy for thoracic disc herniations

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Abstract

Purpose A transthoracic anterior or lateral approach for giant thoracic disc herniations is a complex operation which requires optimal exposure and maximal visualisation. Traditional metal rigid retractors may inflict significant skin trauma especially with prolonged operative use and limit the working angles of endoscopic instrumentation at depth. We pioneer the use of the Alexis retractor in transthoracic thoracoscopically assisted discectomy for the first time.

Methods The authors describe and demonstrate the technical use of the Alexis retractor during operative cases. Patient positioning, clinical rationale and operative nuances are elucidated for readers to gain an appreciation of the transthoracic approach to thoracic disc herniations.

Results The advantages of the Alexis retractor include minimally invasive circumferential flexible retraction, facilitation of bimanual instrument use, diminished risk of surgical site infections and reduced rib retraction leading to less postoperative pain.

Conclusion Use of the flexible and intuitive Alexis retractor maximises operative exposure and is an effective adjunct when performing complex transthoracic approaches for thoracic disc herniations.

Keywords Alexis retractor · Thoracic disc herniation · Discectomy · Myelopathy · Surgical site infection

Introduction

Thoracic disc herniations are often asymptomatic and unrecognised despite constituting between 0.5 and 11.1% cases of degenerative disc disease on autopsy [11, 21]. On the other hand, symptomatic thoracic disc herniations have an estimated incidence of 1 in 1000 to 1 in 1,000,000 and can potentially cause significant neurological deficit [3]. The thoracic spinal cord, tethered by the denticulate ligaments, occupies a relatively large proportion of the relatively narrow thoracic spinal canal. As such, a herniated disc may therefore cause cord compression against the kyphotic thoracic vertebra [16]. This may manifest as thoracic myelopathy with a constellation of pyramidal weakness, sensory alteration and sphincter disturbance [8]. Alternatively, axial back pain from meningeal irritation may also be experienced. Disc herniations occupying more than 40% of the canal are usually labelled as giant thoracic disc herniations [8]. It is these giant herniations requiring operative management that are often calcified and require complex surgical

Previous presentations
No portion of this paper has been presented or published previously anywhere.

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approaches. This may be furthered complicated by the fact that they may extend intradurally in 15% of cases [8].

Treatment of symptomatic thoracic disc herniations poses a unique surgical challenge with three main categories of surgical approaches: posterolateral transpedicular or transdural, postero-lateral with costotransversectomy or lateral transthoracic (retropleural or transpleural) and anterior via a transpleural thoracotomy or thoracoscopically assisted mini-thoracotomy [22, 31]. Softer non-calcified smaller thoracic disc herniations may be amenable to a posterolateral approach. Larger discs have been attempted to be approached posteriorly such as with the posterior transdural approach. However, this necessitates the removal of a significant degree of the posterior elements including a hemi-laminectomy, partial facetectomy and partial medial facetectomy [7, 28]. This is followed by transection of the denticulate ligaments then careful rotation of the spinal cord to open the ventral dura and resect the disc [7, 28]. This remains a technically challenging unfamiliar approach [24]. Various other minimally invasive approaches using tubular retractors have been trialled in feasibility studies, but acknowledge that the infrastructure can be costly to establish with a steep learning curve for surgeons [14, 27]. As such, anteriorly located giant calcified transthoracic disc herniations often require an anterior or lateral access given the need to avoid any manipulation of the delicate spinal cord and the potential for these lesions to be adherent to the dura [40].

The transthoracic approach enables direct visualisation of the disc herniation in relation to the spinal cord and the best exposure as evidenced by a 98% decompression rate on postoperative imaging [1]. This is balanced against potential pulmonary sequelae such as pneumothorax, pleural effusion or chylothorax with a complication rate which ranges from 21 to 39% [5, 40]. Indeed, Shabani *et al.* determined that open thoracotomy resulted in a longer length of stay and increased blood loss [32]. Nonetheless, the ability to perform a bimanual discectomy and directly inspect for intradural extension, whilst avoiding manipulation of the thoracic spinal cord in this vascular watershed zone, remains an advantage [8].

As such, exposure is the key consideration when selecting an appropriate retractor to perform a transthoracic thoracoscopically assisted disc herniation [38]. Traditional self-retaining rib retractors have been used widely, but they may allow tissues to herniate into the field of view and limit the working angles of long surgical instruments. This is especially crucial given the depth of the surgical field at hand. These instruments also spread the ribs with potential neuropraxia and neuropathic pain. The Alexis retractor is a disposable plastic flexible retractor system that is composed of a polymer membrane (Fig. 1) [10]. Each end has a semirigid polymer ring, and multiple sizes are available to ensure an adequate view through the selected surgical incision is possible. After skin incision and soft tissue dissection, the Alexis retractor is passed in between the ribs with one ring inside the thoracic cavity and the other outside the surgical wound.

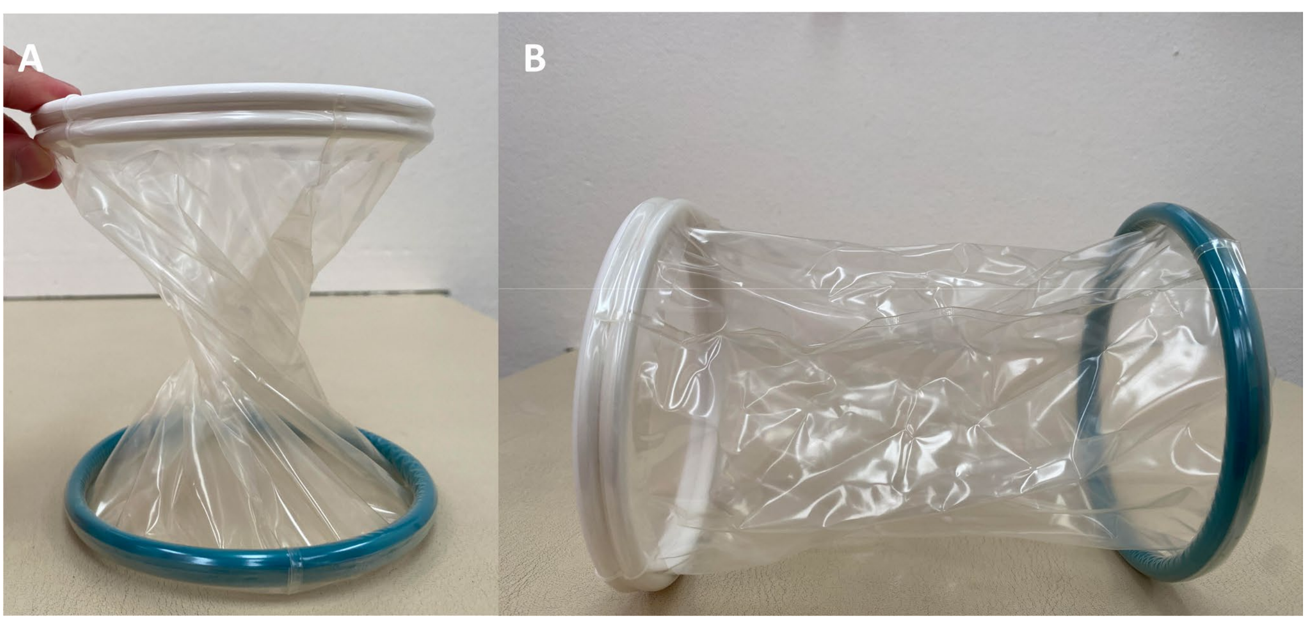

Fig. 1 The flexible nature of the Alexis retractor is demonstrated from an anteroposterior angle (**A**) which highlights its flexibility and ability to be passed easily through the skin incision before being unfurled to provide circumferential view of the wound and unimpeded access to the surgical cavity (**B**)

Advantages of this flexible retractor system include 360° circumferential retraction of the entire wound edge that optimises visualisation when using the microscope and prevents blood from the soft tissue entering and obscuring the surgical field compared to the traditional spatula retracting systems. There is also less fixed rigid pressure on the retracted lung from this dynamic flexible retractor compared to traditional rigid spatula-based systems. Emerging evidence also indicates this system may reduce the risk of surgical site infection [18, 26, 33, 37].

Limitations of the Alexis retractor include the need to ensure the correct angle of docking as the working channel is smaller than regular rib spreaders such as the Finochietto or Harken retractors. Additionally, if a thoracoscope is being utilised to perform the discectomy, then two ports (one cranial and one caudal to the retractor) may be required to optimise visualisation in cases where the disc prolapse extends behind both vertebral bodies (Fig. 2). If single port use is desired, this is sometimes feasible if a 30°-angled thoracoscope is employed to facilitate adequate visualisation the surgeon is able to safely perform the discectomy. In the authors' experience, working at depth in patients with large chest cavities and therefore distance to the surgical thoracic discectomy target with the conventional microsurgical technique may be more challenging than the thoracoscopic technique. At our institution, the proportion of utilisation of each technique is roughly equal and selected based upon specific patient factors such as depth of working field.

Illustrative cases

Case 1: Discectomy with surgical microscope

A 38-year-old female presented with 6 months of progressive left leg weakness. She was profoundly myelopathic on examination with a sensory level at T8. CT and MRI confirmed a large calcified thoracic disc at T5/6 (Fig. 2). She underwent an axillary mini-thoracotomy for microscopically assisted transthoracic discectomy.

Fig. 2 Preoperative magnetic resonance imaging (MRI) of the cervical spine in the sagittal (**A**) and axial (**B**) planes demonstrating a large left paracentral T5/6 disc herniation causing significant cord compression. Postoperative computed tomography (CT) in the sagittal (**C**) and axial (**D**) planes demonstrate left-sided partial vertebrectomy of T5 and T6 as well as resection of the 6th rib head for resection of the thoracic disc herniation

Case 2: Thoracoscopically assisted

A 44-year-old supermarket worker presented with a 3-year history of thoracic myelopathy. On examination, he had a very unsteady broad-based gait and was unable to complete a tandem gait. A sensory level was elicited just above the umbilicus on both sides. In the lower limbs, he had normal tone without clonus, power was 5/5 globally. There was hyperreflexia at the ankles with equivocal plantars.

Magnetic resonance imaging (MRI) of the thoracic spine demonstrated a large right-sided T8/9 disc herniation causing cord compression with cord signal change (Fig. 3) which was not significantly calcified on computed tomography (CT). Given the clinical picture was consistent with thoracic

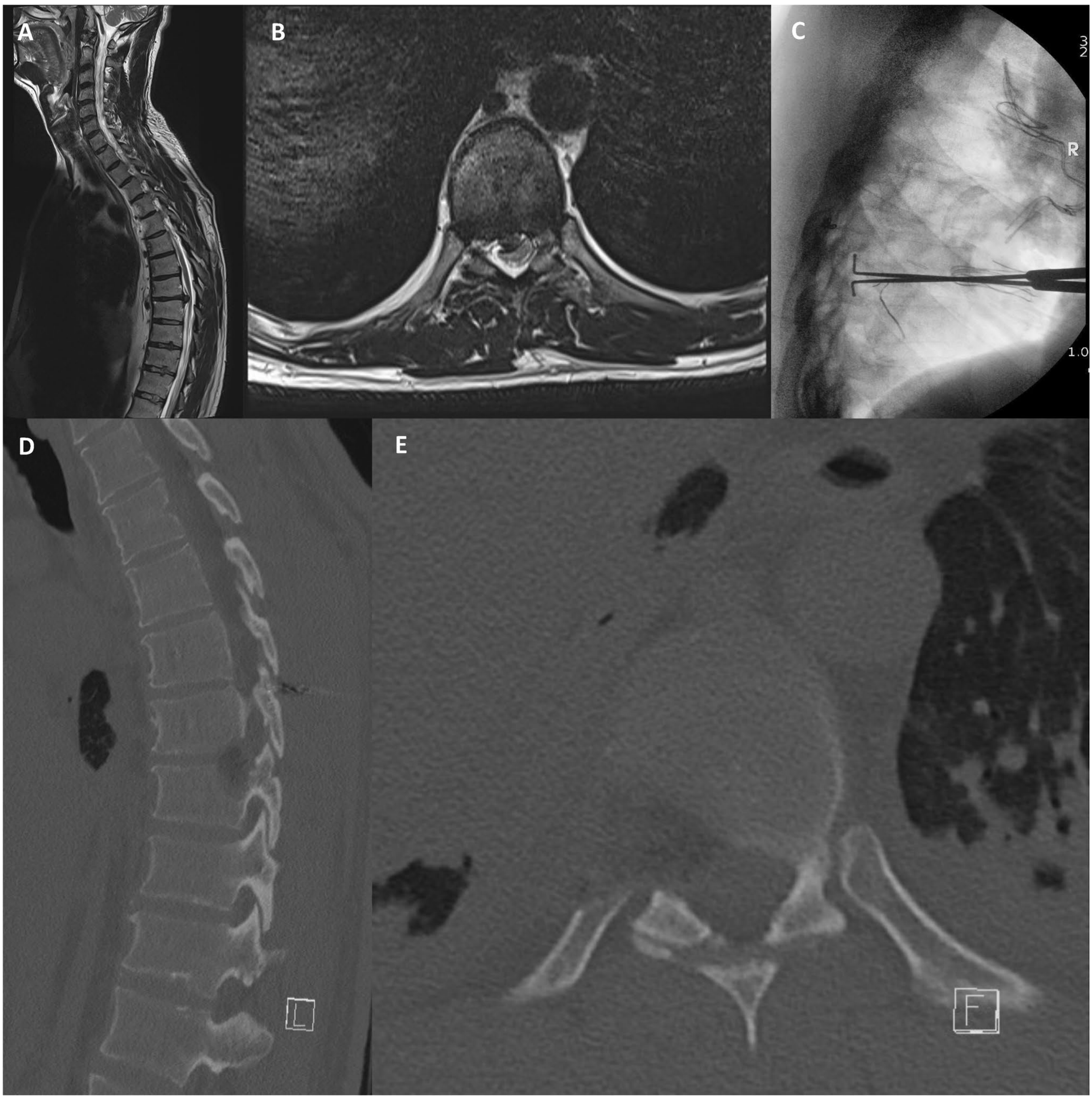

Fig. 3 Preoperative magnetic resonance imaging (MRI) of the thoracic spine in the sagittal (**A**) and axial (**B**) planes demonstrating a right paracentral T8/9 disc herniation causing significant cord compression with early signal change. An intraoperative X-ray confirms the correct level (**C**). Postoperative computed tomograph (CT) in the sagittal (**D**) and axial (**E**) planes demonstrates resection of the posterosuperior portion of the caudal T9 vertebra and 9th rib head to facilitate access for resection of the thoracic disc herniation

myelopathy secondary to this thoracic disc prolapse, it was deemed reasonable to proceed with thoracoscopic transthoracic discectomy without instrumentation.

Both patients provided written informed consent for their case and images to be published in keeping with the 1964 Declaration of Helsinki.

Surgical technique

The patient is positioned in a lateral decubitus position with a double-lumen endotracheal tube in situ and intraoperative neuromonitoring utilised. The authors usually select the side of approach depending on the site of maximal compression, and if a disc herniation is truly midline, then the approach is selected based upon the position of the aorta. In the lower thoracic spine, the aorta is usually in the midline, and therefore a left side access may be easier to avoid retraction on the liver and the need to divide the diaphragm [36]. In case one, a left-sided approach was chosen given the disc prolapse was slightly paracentral to the left, and therefore this approach was ipsilateral to the compressive disc herniation. Conversely, in case two, a right-sided approach was chosen based upon the same rationale of the compression being due to a right-sided thoracic disc herniation.

At the thoracolumbar junction, some authors argue that minimal diaphragmatic division has few clinical consequences, but it is our preference to avoid this if possible [32, 36]. The exception to this is when a previous approach to the thoracic spine, either at the same level or an adjacent level, has been performed. In these instances, it is preferred to utilise the same side of the approach to avoid sacrificing segmental vessels contralaterally which carries the potential risk of spinal cord ischaemia [17, 22]. An axillary roll is placed and pressure areas are appropriately padded. The lower leg is flexed, whilst the upper leg is straight.

A 5- to 6-cm skin incision is marked co-linear to the angle of the rib (Fig. 4). Local anaesthetic is used to infiltrate the wound, and the latissimus dorsi is mobilised and preserved. Serratus anterior is divided in the line of its fibres to expose the rib which is one or two levels higher than the intended discectomy level. We normally select the intercostal space with intraoperative imaging intensifier prior to prep and drape. The intercostal muscle is divided, and the lung

Fig. 4 Intraoperative photographs of the positioning and demonstration of the small 6-cm incision made to facilitate access with the flexible and clear Alexis retractor for primary access to the target thoracic disc level (**A**). A second smaller incision is made inferiorly to introduce the thoracoscope (**B**). The Alexis retractor is being unfurled internally and is being docked (**C**) before bimanual instrument use with the suction, and drill is made possible with unimpeded access provided by the Alexis retractor (**D**). Direct visualisation with the thoracoscope through the second smaller incision is performed (**E**), and it is possible to visualise the edges of and access provided by the circumferential Alexis retractor. The wound is well healed on the final follow-up (**F**)

deflated before being mobilised anteriorly. At this point, an appropriately sized Alexis retractor is placed. An intraoperative XR (Fig. 3) is taken to confirm the disc level by visualising a preoperative pedicle marker (coil) placed by interventional radiology prior to surgery [9].

A second caudal smaller incision is made to allow the entrance of the thoracoscope through a 5-mm port (Fig. 4). The rib head articulating with the index vertebra is resected to expose the endplates at the disc level. Additionally, the cranial portion of the pedicle, which belongs to the caudal vertebra, is partially removed as required. The segmental vessels, traversing the middle of the vertebral bodies, are preserved if possible. The drill and Sonopet Ultrasonic Aspirator are employed to expose the intervertebral disc space (Fig. 5). The annulus is then incised, and the discectomy is performed in an antero-posterior direction, leaving the fragment in the canal as the last portion to be removed in order to avoid retraction on the spinal cord (Fig. 5). The posterior longitudinal ligament is eventually identified and divided if necessary. For heavily calcified discs, we normally perform a partial vertebrectomy in a fish mouth shape of both the caudal and cranial vertebrae (Fig. 2). The patient is clinically assessed postoperatively, and magnetic resonance imaging may be obtained to confirm adequate surgical decompression.

Discussion

Symptomatic thoracic disc herniations have the potential to cause significant debility secondary to thoracic myelopathy [2]. Anterior-calcified giant thoracic disc herniations usually require an anterior approach with transthoracic access [4, 8]. In these cases, exposure to enable direct visualisation of the thoracic disc is critical [15]. Traditional rib spreaders or retractors have the disadvantage of being high profile and often obstruct surgical visualisation of the pathological level whilst also necessitating significant rib retraction [35]. For this reason, the authors have pioneered the novel use of the Alexis retractor which has several advantages.

Firstly, the Alexis retractor enables circumferential retraction of soft tissue allowing unimpeded access to both directly visualise the thoracic disc herniation and pass instruments into the field of view. This has been a major benefit that has led to the increasing use of the Alexis retractor and its adoption by other surgical specialties. For example, the Alexis retractor system has been successfully employed and described by Mubeen *et al.* in oral and maxillofacial surgery, Perenyi *et al.* in transoral robotic surgery, Sidhu *et al.* in radical cystectomy, Mothiba *et al.* in caesarean sections, Wong *et*

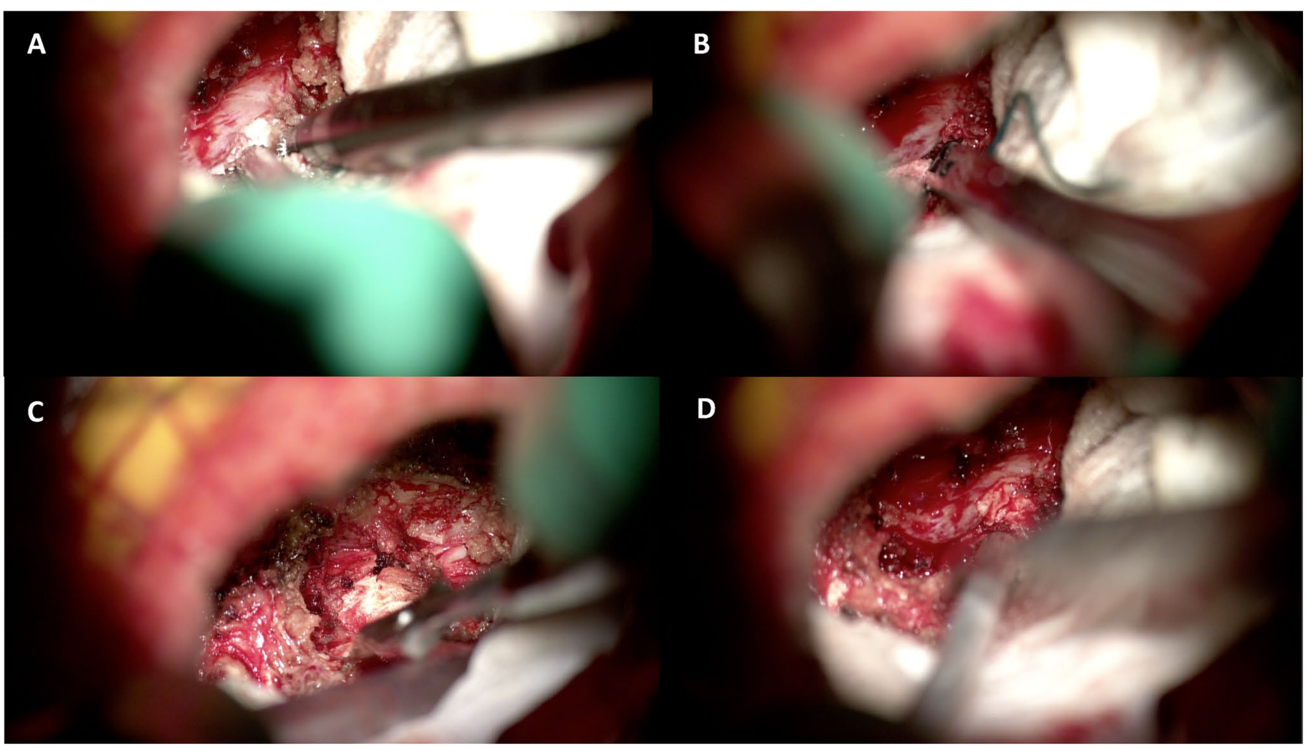

Fig. 5 Microsurgical view of the thoracic discectomy being performed with bimanual instrument use with the high-speed drill to perform removal of the vertebra and rib head which facilitates access to the thoracic disc herniation, whilst simulation suction of the debris is performed (**A**). A Kerrison Rongeur is used to complete the discectomy (**B**) with sequential sharp incision of the discectomy to perform piecemeal removal (**C**). Methodical removal of disc fragments to complete the discectomy and ensure adequate cord decompression is ergonomic and assisted by the excellent retraction provided by the Alexis retractor (**D**)

al. in lateral orbital access and Horiuchi *et al.* in atraumatic gastrointestinal surgery [13, 20, 25, 26, 29, 33, 37]. Furthermore, the polymer material provides atraumatic retraction and maximises the exposure with a small incision site associated with a mini-thoracotomy used in this approach. This also facilitates hands-free retraction enabling the assistant to perform more interactive duties such as holding the endoscope during the surgical decompression as well as minimising hand fatigue for more critical components of the surgery [34].

An additional benefit from Alexis retractor use in this setting is the reduced rate of surgical site infection which has been observed (Table 1) [23]. Mohan *et al.* cultured the plastic material of the Alexis retractor from samples inside the retractor compared to outside the retractor and determined there was a lower rate of colonisation (56% vs 34%, $p < 0.0001$) [23]. This translated into clinical benefit with Lee *et al.* finding a lower incidence of wound infection in open appendicectomies compared to traditional retraction (1.6% vs 14.6%, $p = 0.02$) [18]. A similar finding has been found in atraumatic gastrointestinal surgery by Horiuchi et al. and in the colorectal surgery cohort by Reid et al. [13, 30]. These are similarly large cavities for which exposure is critical to reach structures at a depth similar to a transthoracic anterior approach. Most importantly, Hinkson *et al.* and Mothiba *et al.* compared the Alexis retractor to a bare metal retractor similar to the rib retractor usually employed and found that the rate of surgical site infection was statistically lower with the former [12, 25, 39].

Moreover, there is emerging evidence that the even distribution of forces from circumferential retraction creates a tamponade effect and minimises blood loss [12]. The Alexis retractor also maintains moisture especially for prolonged cases such as complex anterior thoracic discectomies. The clear plastic material of the retractor facilitates easy wound inspection to ensure that the edges of the exposure are not being discoloured which may suggest ischemia and prompt repositioning by the surgeon. Not only does the Alexis device serve as a retractor, it also protects the wound from any intraoperative fluids or material such as bone dust which may compromise lateral wound healing [12]. For these reasons, Horiuchi *et al.* specifically examined cases of Alexis retractor use in patients undergoing caesarean section who were on steroids and who are at particularly high risk of wound complications and surgical site infection [13]. Strikingly, even in this cohort, the rate of surgical site infection was lower with Alexis retractor use compared to the traditional Collins metal retractor [13].

A further consideration of utilizing a disposable retractor system versus a reusable system is economic feasibility. At our institution, a standard Alexis retractor costs between $80 and $100, whilst the cost of sterilisation of a reusable rib retractor system is approximately half this cost. Nevertheless, there are several advantages of the disposable system which include mitigation of the large initial investment fees on different reusable retractor systems based on competing surgeons' preference. More than this, there is no concern that multiple specialties will require the same retractor system simultaneously. Finally, there is no requirement for ongoing maintenance or burden on the sterilisation service when a readily available disposable easily accessible Alexis

Table 1 Baseline study and patient demographics of the pooled literature on the use of Alexis retractor in surgery

Study	Country	Study design	Study period	Total sample size	Surgical cohort	Comparison retractor	Infection rate
Horiuchi et al. (2005) [13]	Japan	Prospective randomised	2003–2004	354	Atraumatic gastrointestinal surgery	No retractor	8.1% vs 0%, $p = 0.0021$
Lee et al. (2009) [19]	United States of America	Prospective randomised	2006–2008	109	Open appendicectomy	Traditional retractor arm	14.6% vs 1.6%, $p = 0.02$
Reid et al. (2011) [30]	Australia	Prospective randomised	2007–2010	135	Colorectal surgery	Retractor of choice (Surgeon preference)	22.7% vs 4.7%, $p = 0.004$
Cheng et al. (2012) [6]	Malaysia	Prospective randomised	2008–2010	72	Colorectal resections	Balfour retraction and 4 abdominal packs	20% vs 0%, $p = 0.006$
Hinkson et al. (2016) [12]	Germany	Prospective randomised	2013–2015	214	Caesarean section	Collins metal self-retaining retractor	8% vs 1%, $p = 0.035$
Sidhu et al. (2018) [33]	United States of America	Retrospective cohort	2010–2017	237	Radical cystectomy	Bookwalter retractor	11% vs 3%, $p = 0.092$
Mothiba et al. (2023) [25]	South Africa	Prospective randomised	2015–2016	207	Caesarean section	Metal retractor	0% in both groups

system is available in a range of sizes tailored to the individual patient.

Future studies could focus on translating the use of the Alexis retractor into lateral approaches to the lumbar spine including anterior to psoas approaches or transpsoas approaches. Larger multi-centre randomised trials would assist in demonstrating and quantifying the utility of the Alexis retractor. This technical note demonstrates our positive experience with this system at our institution, but specific individual patient scenarios and surgeon familiarity with existing equipment should also be taken into consideration given the most important outcome is delivering efficient patient care.

Conclusion

We pioneered the use of the Alexis retractor in transthoracic thoracoscopic discectomy for the first time. The advantages include circumferential flexible retraction, facilitation of bimanual instrument use, reduced rib retraction, early mobilisation, reduced rib retraction with improved postoperative pain and diminished risk of surgical site infections.

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Code availability Not applicable.

Author contribution All authors whose names appear on the submission made substantial contributions to the conception, design, interpretation of data, drafting and review of the final manuscript.

Data availability Not applicable.

Declarations

Ethics approval Both patients provided written informed consent for their case and images to be published in keeping with the 1964 Declaration of Helsinki.

Consent to participate The patients provided written informed consent to participate in this study.

Consent for publication Both patients provided written informed consent for their case and images to be published in keeping with the 1964 Declaration of Helsinki.

Conflict of interest The authors declare no competing interests.

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