Introduction:

Over the last few years, robot-assisted surgery has gained in popularity and has become increasingly accepted in variety of surgical disciplines, including spine surgery. This is notably due to the growing number of literature reports evidencing the greater precision and lower complication rate associated with robot-assisted techniques.[1,2] Percutaneous spinal surgery for herniated disc (first described in 1980) has earned a reputation as a minimally invasive technique that - in experienced hands – results in minimal tissue damage.[3,4] Here, we describe the combination of these two advanced techniques in the instrumentation-free treatment of herniated lumbar disc using the ROSA® robot (Medtech, Montpellier, France), the O-arm® scanner (Medtronic, Minneapolis, MN, USA) and the EasyGO® second-generation endoscope (KARL STORZ, Tuttlingen, Germany). Use of these devices enabled us to treat 20 patients without causing any nerve injuries or dural tears.

To the best of our knowledge, the present study is the first to have described the combined use of the ROSA® robot and the EasyGO® second-generation endoscope in the instrumentation-free treatment of herniated disc.

Methods

The patient gave his consent for the publication of anonymized photos and videos for research purposes. Likewise, all medical staff in the photos and videos gave their consent to publication.

Installation of the ROSA® robot with the O-arm® scanner

Under general anesthesia, the patient is placed in prone position on a Wilson frame mounted on a radiolucent spinal operating table. The abdomen hangs freely, and the spine is flexed to open the interlaminar space. Care should be taken to ensure that all pressure points are adequately padded. The O-arm® device is set up around the patient, and the ROSA® spine robot is set up to the right of the patient (at an angle of 45°) (Figure 1). As with all minimally invasive neuronavigation procedures, a percutaneous reference frame with reflective navigation markers is attached to right or left posterior iliac crest (for left-side or right-side herniated discs, respectively) through a paramidline incision (Figure 1). Next, the O-arm® device is used to acquire a three-dimensional CT scan.

Installation of the tubular retractor and the endoscope

After the image from the O-arm® CT scanner has been transferred to the ROSA® spine robot’s surgical workstation, a trajectory is planned so that the tubular retractor is aligned with the disc as well as possible. This is the safest trajectory, i.e. one that will not damage the dura, the nerve roots, the facet joint or the pedicle (Figure 2, Video 1). The surgical site is then prepared and draped in a sterile manner. A skin incision is made (with robotic guidance) at the angle required by the chosen trajectory. This is usually an 18-20 mm incision, located 1.5 cm lateral to the midline on the side of the herniated disc (Figure 3, Video 2). A tubular retractor of the appropriate length is then put in place. Once the position has been checked with the navigation system, the tubular retractor is locked to a flexible arm assembly system attached to the operating table. The endoscope’s holding arm is set up on the opposite side of the
hernia (Figure 4). The robot is moved away and kept sterile, to make space for the surgeon (for a left-side hernia) or the instrument (scrub) nurse (for a right-side hernia). Next, the endoscope is inserted into the tubular retractor and secured to it via the locking arm on the ring attachment (Figure 5). If the endoscope comes in contact with the soft tissue and smudging occurs, the instrument can be removed and cleaned (using antifog solution and gauze). The camera can also be cleared by irrigating with saline solution while the endoscope is inside the tubular retractor.

Soft tissue removal, bone drilling, and discectomy

Firstly, the lower edge of the superior lamina is identified by dissection using either a pituitary rongeur or a long-tipped, insulated Bovie electrocautery device. The lower edge is then removed (using a Kerrison punch or high-speed drill) until hemilaminotomy or medial facetectomy has been achieved. During this phase, it is essential to periodically confirm the position and compliance with the preplanned trajectory, using the navigation system (Figure 6). Once partial flavectomy has been performed and the lateral edge of the dural sac and the traversing nerve root (5–10 mm) become visible, they are retracted medially using a Penfield dissector or a Love-style or suction retractor (as used in conventional hernectomy, annulotomy and/or discectomy). After checking for any epidural bleeding (using a bipolar forceps, if needed) and confirming hemostasis, the flexible arm assembly is loosened and the tubular retractor is removed slowly. If there is bleeding from the paraspinal muscles, it can usually be controlled with the bipolar forceps. The fascia is approximated with one or two interrupted stitches of absorbable suture. The subcutaneous tissue is closed in an inverted manner, and the skin is closed with subcuticular suture. Lastly, a dressing is applied.

Discussion:

Since Krause’s first description of the open surgery for lumbar disc herniation in 1908, the surgical management of this condition has evolved towards minimally invasive, less traumatizing techniques.[5] The first minimally invasive approach was described in 1964, with the use of chemonucleolysis by compounds in papaya latex.[6] Hijikata’s first use of percutaneous nucleotomy in 1975 was followed by Yasargil and Kaspar’s description of microscope-assisted discectomy in 1977.[7,3,4] Ten years later, Kambin and Maroon performed the first percutaneous lumbar discectomy.[8,9] In 1997, Foley and Smith introduced microendoscopic discectomy.[10]

Robot-assisted surgery is being increasingly applied in a range of surgical specialties, including neurosurgery.[11-21] In June 2016, the US Food and Drug Administration approved the use of robot-assisted techniques in spine surgery. In theory, robotic surgery is an ideal way of reducing the frequency of operating errors - especially in spinal surgery, where precise motor control is needed because of the bony structures’ proximity to nerve roots and blood vessels. However, formal recommendations on the wider use of robotic surgery require clinical trials in which these techniques are compared with conventional percutaneous and open procedures. At present, robotic surgery is showing promising results for spinal instrumentation and arthrodesis.[2] Furthermore, robotic surgery appears to reduce the surgical team’s exposure to ionizing radiation, relative to fluoroscopy-guided techniques; only one CT image is required for trajectory planning, and then navigation alone is required to confirm the location.
periodically. This avoids the need for several fluoroscopic images for trajectory planning and location checks.[22] However, these improvements may be associated with an increased cost. In other fields of surgery (mainly obstetrics, gynecology, urology, and colorectal surgery, where robotic surgery has been used since the 1990s), robot-assisted techniques have shown advantages and disadvantages.[23-27]

Here, we described our technique for microendoscopic discectomy using the ROSA® robot, the O-arm® scanner, and the EasyGO® second-generation endoscope. We were able to optimally position the tube retractor and perform laminotomy and flavectomy to an extent that gave us access to the herniated disc. We have operated on 20 patients to date; the postoperative outcomes were good, and the length of hospital stay was usually 2 or 3 days. In the future, we plan to perform microendoscopic discectomy as day surgery. Once we have attained a sufficient patient volume and collected long-term follow-up data, we intend to compare the respective outcomes of the robot-assisted and conventional operating techniques.

**Conclusion:**

Robot-assisted surgical techniques are evolving rapidly. Robotic microendoscopic discectomy using the ROSA® robot, the O-arm® scanner and the EasyGO® second-generation endoscope is feasible. With a view to wider adoption of this technique, comparisons with conventional surgical methods are now required.
References


**Figure legends**

FIGURE 1. The final set-up, showing the ROSA® robot to the right of the patient, and the O-arm® CT device around the patient. Three dynamic reference frames can be seen; two on the ROSA® robot, and one on the patient’s back.

FIGURE 2. The ROSA® spine robot’s surgical workstation is used to plan the safest trajectory.

FIGURE 3. The ROSA® robot’s arm indicates the location and angle of the incision that match the preplanned trajectory.

FIGURE 4. The arrow indicates the tubular retractor, and the arrowhead indicates the flexible arm assembly.

FIGURE 5. The final set-up for dissection. The arrow indicates the endoscope, which is held in place by the tubular retractor.

FIGURE 6. The left side of the image shows the ROSA® robot’s workstation, through which the stereotactic position (and thus compliance with the preplanned trajectory, in blue on the monitor) can be checked periodically during the dissection.

**Video legends**

Video 1. The surgeon uses the ROSA® robot’s workstation to plan the safest trajectory.

Video 2. The ROSA® robot’s arm moves to show the location and orientation required to attain the planned trajectory.