Endoscopic Robotic Decompression of the Ulnar Nerve at the Elbow
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Abstract: Ulnar nerve entrapment can be treated by a number of surgical techniques when necessary. Endoscopic techniques have recently been developed to access the ulnar nerve by use of a minimally invasive approach. However, these techniques have been considered difficult and, many times, dangerous procedures, reserved for experienced elbow arthroscopic surgeons only. We have developed a new endoscopic approach using the da Vinci robot (Intuitive Surgical, Sunnyvale, CA) that may be easier and safer. Standardization of the technique was previously developed in cadaveric models to achieve the required safety, reliability, and organization for this procedure, and the technique was then used in a live patient. In this patient the nerve entrapment symptoms remitted after the surgical procedure. The robotic surgical procedure presented a cosmetic advantage, as well as possibly reduced scar formation. This is the first note on this surgical procedure; the procedure needs to be tested and even evolved until a state-of-the-art standard is reached.

The ulnar nerve stems from the medial cord of the brachial plexus, runs by the medial side of the arm, and rises from the arcade of Struthers in the medial triceps. In the elbow it enters the cubital tunnel. Just after its exit from the cubital tunnel, it enters the arcade of Osborne in the proximal forearm and runs through the medial forearm to the hand. Common areas of ulnar nerve compression are the arcade of Struthers, the medial intermuscular septum, the medial epicondyle, the narrow cubital tunnel, the arcade of Osborne (fibro-aponeurotic tissue connecting the humeral and ulnar heads of the flexor carpi ulnaris), and the aponeurosis of the deep flexor and pronator teres. Furthermore, during elbow flexion, traction forces on the ulnar nerve are major causes of increased intraneural pressure. The cubital tunnel changes from an oval to a flattened ellipse, where flexion pressures within the tunnel may increase by 7 times. In throwing athletes the ulnar nerve pressure can be enhanced up to 6-fold from the resting position to the cocked throwing position. The elevation of the pressure at these sites also can be related to some compressive pathologies, such as tumors, cysts, and anconeus epitrochlearis, as well as other causes.

When surgery is necessary, there are many surgical techniques available for both the nerve release and the nerve anteriorization. Endoscopic techniques have recently been developed to access the ulnar nerve, enabling the surgeon to use a minimally invasive approach. Some of these techniques have only been used in cadaveric models. Others have been considered very difficult and even dangerous procedures, reserved for highly experienced elbow arthroscopists only.

New endoscopic techniques with new devices could make the endoscopic decompression and/or anteriorization of the ulnar nerve a safer and easier procedure. We suggest that the use of robotic technology can be an option to endoscopically access the ulnar nerve and its entrapment sites in an easier and safer manner.

Surgical Technique

The surgical technique was developed by adapting the open surgical technique of robotic anterior translocation of the ulnar nerve to endoscopy. We used a new docking and setup for the da Vinci robotic system (Intuitive Surgical, Sunnyvale, CA) based on the previous knowledge of endoscopic robotic techniques related to different surgical areas, such as urology and gynecology.

Before we used the new surgical approach in a live patient, it was successfully tested in 2 cadaveric models.
The patient underwent general anesthesia and was placed in the supine position with the left arm raised 170°, in a Trendelenburg position of 20°. The arm lay on the surgical table next to the patient (Fig 1).

Because there are no natural cavities in the ulnar nerve pathway, its endoscopic access requires the creation of an initial cavity. A small cavity is created in the middle third of the arm. This cavity will be opened through a 1.2-cm portal, the exact length of the da Vinci robot’s cannula. Dissection of the cavity is performed just above the ulnar nerve with Metzenbaum scissors. Through this portal, an initial subcutaneous cavity is created and directly faces the ulnar nerve. Its dissection is directed to the distal arm (Figs 2 and 3). The 2 other portals are created in the division of the middle and distal thirds of the arm, 2 to 3 cm lateral and medial to the first portal. These 2 portals need to be 8 mm long to allow the cannulas of the robotic hands to pass. These cannulas need to be gently inserted in the direction of the cavity to avoid any lesion. Once the robotic hands are visible by the optics in the cavity, they can distally expand this cavity. Only these 3 portals are used.

Sometimes, a needle can be used to certify the best location of the 2 aforementioned portals. It is important that the secure distance mentioned earlier be reached between the portals to avoid conflict of the robotic arms (Fig 4). The third robotic arm is not used in this procedure. The insufflation of air at a pressure of 10 mm Hg is used to avoid bleeding. Saline solution of 0.9% can be introduced and aspirated to clean the surgical field.

After docking the robot’s parts and creating the portals, the surgeon uses the console to operate the robot from a distance (Fig 5). The surgeon performs the surgery seated in an ergonomic position using the first and second fingers and 3-df robotic arms. These robotic arms allow wrist movements, improving the surgeon’s movement capabilities. The surgeon can scale the movement up to 5-fold, adding more precision to the robotic arms.

The robotic arms in our setup hold 8-mm curved scissors (Intuitive Surgical) and Maryland bipolar 8-mm forceps (Intuitive Surgical). Through this approach, the surgeon is able to access adherences that have formed next to the nerve path, open the medial posterior elbow capsule, and decompress the cubital tunnel as in an open procedure (Figs 6–8, Video 1).

The 3-dimensional view provided by the robot’s stereoscopic optics makes the learning curve for using the
described technology very short. Anterior translocation of the ulnar nerve or its simple release is possible because the robotic arms present 3 df; therefore the movements are similar to those of free hands.

After the development phase in the cadaveric models, 1 patient underwent the procedure. The patient, a 36-year-old woman, was informed that all data concerning her case would be submitted for publication, and she gave her written informed consent.

The patient presented with elbow stiffness due to a radial head fracture. After arthroscopic release, arc of motion increased for both flexion and extension; however, the patient had ulnar nerve impingement symptoms. This situation occurred because of 2 complications: (1) a decrease in the cubital tunnel diameter, probably due to morphologic alterations of the medial collateral ligament and other fibrous structures of the cubital tunnel as part of the stiffness, and (2) scar formation due to the medial portal in the elbow, which was sometimes too close to the ulnar nerve.

When the patient had an increase in flexion, the nerve entrapment became more evident. Posteromedial elbow pain during flexion movements during physical therapy prevented a greater increase in flexion.

An electromyographic examination was performed, and the results showed major entrapment of the ulnar nerve in the cubital tunnel with no lesion. Therefore a procedure comprising posteromedial capsule and ulnar nerve release was performed. After surgery, elbow flexion could be increased without posteromedial pain and the ulnar nerve commitment signs and symptoms remitted.

Discussion

Telesurgery has been used widely in urology, gynecology, and other surgical specialties. Orthopaedic surgery has just recently added this technology for open brachial plexus reconstruction, as well as microsurgical nerve procedures. The advantages of robotic surgery are as follows: (1) Tremor filtration makes the surgical procedure stable
and controlled. (2) Magnification of the image makes it possible for the surgeon to better explore the surgical field. (3) Scaling of surgical gestures is possible; the surgeon can scale the movement up to 5-fold to gain more precision. (4) The 3-dimensional view makes the procedures more intuitive and the learning curve shorter. This is made possible by use of the da Vinci stereoscopic optics. (5) The instruments have 3 df. The devices used in robotic surgery present movements similar to the natural movements performed by surgeons’ hands during open surgery; they even allow wrist movements. (6) Ergonomics is improved because the surgeon is out of the surgical field, seated in a comfortable position.13

Future technologies, which are currently under development, will also allow the surgeon to browse the Internet, ask the opinion of another colleague online during the surgical procedure, use just a single portal for endoscopic approaches, perform local microscopic examinations in real time by using a microscope docked to the robot, and use specific markers that will provide a more reliable identification of the target structures.

The negative points and limitations of this new technology are as follows: high costs, absence of haptic feedback, the fact that the instruments have not been designed for orthopaedic procedures, and the absence of surgical procedure standards. However, it is suggested that the absence of haptic feedback does not influence the results of many kinds of soft-tissue operations.17 It is also expected that future robots will even be able to present scaled haptic feedback, solving this problem and improving this perception.

Surgeons without specific training in robotic surgery can yield risks for patients undergoing these procedures. Thus the robotic manufacturer gives them an introductory course. This allows a safer and more rational use of the robot.

Surgical risks can be mitigated by following a standardized protocol. We tested the described procedure in 2 cadaveric models before we tested it in a live patient so that we could standardize the robot docking, position the robotic arms, open a cavity, and create the portals. Regarding orthopaedic surgery, there is a long way to go because there is still a complete lack of standardization for orthopaedic surgery.

The costs of the robotic hands are high but can be mitigated because they are designed to be used 10 times. The learning curve in telerobotic endoscopy is not long because the 3-dimensional view allows the visual depth, bringing the surgeon to the real visual world; moreover, the intuitive movements provided by the controls in the console replicate the real movements used during an open procedure.

There are some limitations to this procedure related to small and thin patients because the surgeon is unable to reach an ideal size of cavity to introduce the robotic hands and the optics. Perhaps future robots will have smaller diameters, allowing universal use of this procedure.

This is the first reported technique of an endoscopic robotic approach to access the ulnar nerve. This first elbow procedure was simple in order to better establish the portals and the endoscopic landmarks. The robotic surgical procedure presented a cosmetic advantage, as well as possibly reduced scar formation, in the live patient. An endoscopic robotic approach to the ulnar nerve is possible and can be a surgical option; however, knowledge of the regional endoscopic anatomy and training in robotic surgery are necessary to use this technology.

References
