Lithotripsy of Renal Stones With Avicenna Roboflex Robotic-Assisted Retrograde Intra-Renal Surgery (RA–RIRS)

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ABSTRACT

The role of retrograde intra-renal surgery (RIRS) with flexible ureterorenoscopy (FURS) in the management of kidney stone formation has garnered a prevalent use among urologists thanks to new improvements in medical equipment; however, it still remains a challenging technique. The purpose of this chapter is to overview robotic assistance for RIRS and mainly focus on ELMED’s robotic device by thoroughly describing it and investigating its effects on surgical performance based on the IDEAL (idea, development, evaluation, assessment, long-term study) framework. The robotic device, Avicenna Roboflex, is a teleoperated robot consisting of a surgeon’s console (master control console – MCC) and manipulator arm (MA) to house and couple with the FURS. It provides a suitable and safe platform for robotic-assisted (RA) RIRS with significant improvements in ergonomics and potentially prolongs equipment durability which may lead to its general acceptance and preference of use by many surgeons in various countries including Turkey, Germany, France, the UAE, and Romania.

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INTRODUCTION

In this chapter, the authors overview the field of Robot Assisted Retrograde Intra-Renal Surgery (RA-RIRS) motivated by the state of the art in the field, and introduce an innovative robotic solution for flexible ureterorenoscopy, the Avicenna Roboflex (ELMED, Ankara, Turkey, 2012). It is the first commercially available robotic master control console (MCC) and manipulator arm (MA) for remote control of all commercial flexible ureterorenoscopes equipped with functions, such as rotation, deflection, insertion and retraction, used in Robotic Assisted Retrograde Intra-Renal Surgery (RA-RIRS). The reader is first presented with key descriptions and the status quo of existing robotic solution for flexible ureterorenoscopy prior to the arrival of Avicenna Roboflex in order to gain insight to surgical specifications robotic assistance needs to comply to, followed by an introduction into the IDEAL framework as a means of evaluating surgical innovations. Then, the focus turns into explaining the need for a robotic option for RIRS, with a thorough explanation of functionalities provided by the robot related to task specific requirements. Effectiveness of the device is later evaluated, introducing an application of the IDEAL framework to the reader. Lastly, certain additional features are presented, which can further enhance the effectiveness of the robot.

To briefly introduce the robot, Avicenna Roboflex is an interface between a surgeon and the surgical equipment needed for flexible ureterorenoscopy (FURS). It allows the surgeon to fine-tune the endoscope tip control by choosing low or high precision in movement scaling and enables more dexterity in tip rotation when compared to manual operation. Beyond that, the scope used can be selected by the surgeon among various EU- and US-types, providing greater versatility in the choice of the end effector. The scope can be fixed in position as well, allowing continuous access to the target and preventing surgeon fatigue by manipulating the scope in a comfortable seated position instead of a hard-to-maintain standing bent posture for the necessary scope tip orientation. It also keeps the surgeon outside the radiation field eliminating the need to wear any lead protection, which in turn improves surgeon performance through better comfort and dexterity and reduced physical fatigue. Avicenna Roboflex provides an interface for laser fibers that fire pulsed (or continuous wave) laser beams which create vaporization bubbles that in turn fragment renal stones, and incise or ablate soft tissue. The tracking of the laser beam nozzle tip and the precise remote advancement-retraction controls are key for preventing unintended laser firing near the scope tip; thus, accidental shots, and consequent damage to the scope tip are avoided, leading to instrument longevity. Precise pulsed laser stone fragmentation has made it possible to treat larger intra-renal stones, which was impractical before and required lengthy procedures of great discomfort. Additionally, video processing and computer measurements are overlaid, providing a better awareness and orientation without any need of looking to separate control screens. Being potentially adaptable as an interface for all endoscopic equipment, Avicenna Roboflex may also decrease required manpower to perform any surgical and diagnostic endoscope based procedures.

Thus, this chapter aims to provide the detailed description of this system, compare it to other commercially available robotic surgical systems and present details on the development process of the device designed and manufactured by ELMED (Ankara, Turkey), from prototype to commercialization. The authors will also provide surgical innovation analyses of Roboflex Avicenna (IDEAL stage 1), and summarize its early clinical experience with treatments performed by different experienced surgeons (IDEAL stage 2).