Flexible Ureteroscopy Robot RobofleX Avicenna and Robotic Retrograde Intra-Renal Surgery – Lithotripsy
Descriptions:

- Non-Invasive / minimal invasive
- Urinary System
- Endoscopy
- Uretero–Reno Scopy: URS
- Robots
- F–URS: Flexible URS
- LASER Lithotripsy
- RIRS: Retrograde Intra Renal Surgery
- Robotic Surgery
Minimal Invasive Techniques

- Non-invasive
  - ESWL

- Minimal invasive
  - Laparoscopy/SILS–SPA
Urinary System
Urinary Stones
Endoscopical Stone Management

- Cystoscopy
- PCNL – Nephroscopy
- UreteroRenoScopy: URS
- Flexible URS: fURS
The surgeon has to perform this procedure mostly in a standing position with suboptimal ergonomy. It may be one of the reasons for the need of second session and frequent repair of the endoscopes.
Prevalence of orthopedic complaints among endourologists and their compliance with radiation safety measures.

Elkoushy MA, Andonian S
Department of Urology, McGill University Health Centre, Montreal, Canada. 

Hand problems among endourologists.

Healy KA, Pak RW, Cleary RC, Colon-Herdman A, Bagley D
Department of Urology, Thomas Jefferson University, Philadelphia, Pennsylvania, USA. 

CONCLUSIONS
Future studies are needed to develop more ergonomic platforms and thereby reduce the endourologist's exposure to these occupational hazards.
Why a robot is necessary for flexible URS?

- Flexible ureterorenoscopical treatment of the kidney stones has become a widely used procedure and now there are new attempts for treatment of larger stones.
- According to the leading urologists, the future of the endourology will be using robots.
- We need to find a new method operating in a seated position far from radiation, without wearing lead apron and remotely control all of the functions of the flexible ureterorenoscope.
Why a robot is necessary for flexible URS?

- **To prevent the doctor,**
  - Providing better ergonomics and prevent fatigue,
  - Preventing the user from the radiation exposure.

- **To prevent the device,**
  - Using it always in a straight position,
  - Not to twist the shaft,
  - Preventing the laser shot, while the tip of the fiber is very close to the tip of the device.
Short History of Surgical Robots

The company **Motion Control**

1990 AESOP (Automated Endoscopic System for Optimal Positioning),

1994 FDA approval of AESOP

1995 ZEUS

2000 FDA approval

2006 Da Vinci S system

2009 Da Vinci Si system

ZEUS DISCONTINUED

INTUITIVE SURGICAL

The company **Intuitive Surgical**

1999 Da Vinci Robot

2003 **Motion Control + Intuitive Surgical**

The company **Hansen Medical** was founded by Dr. Frederic Moll, who had also co-founded Intuitive Surgical, Produced Sensei X

Remote catheter control system

1136–1206 El Cezeri
1452–1519 da Vinci
El Cezeri (1136-1206)
the chief engineer of the Artuklu palace in Mardin-Turkey
He wrote an illustrated manuscript kept on Turkish museum and Louvre museum in Paris.
He designed and produced many type of robots, most of them powered by water, some of them related with medicine.
The beginning

- We tried to use Storz FlexX2 with a simple attachment,
Later we developed the first robotic manipulator. We named this new robot «Avicenna RobofleX»
Avicenna (980–1037)
Is a well known medical scientist and philosopher
Avicenna’s book “The Rules of Medicine” has been taught for over 400 years in the Andalucian and European medical schools.

A Latin copy of the *Canon of Medicine*, dated 1484, located at the P.I. Nixon Medical Historical Library of the University of Texas Health Science Center at San Antonio.
First Robot in the World for RIRS–Laser Lithotripsy

Avicenna Roboflex
There are more reasons to develop a new robot for flexible Ureteroscopy (FURS)

To provide better treatment of the patient

- To be able to rotate, more than manual,
  - manually 120° rotation
  - robotically 440° rotation (almost 1 ¼ turn)
There are more reasons to develop a new robot for flexible Ureteroscopy (FURS)

➢ To be able more precise deflection
  - manually 10° deflects the tip 60°
  - robotically 10° deflects the tip up to 3°

IT MEANS THAT, ROBOFLEX IS 20 TIMES MORE PRECISE THAN MANUAL USE

➢ We need to reverse sometime EU type to the US type.

Traxer
There are more reasons to develop a new robot for flexible Ureteroscopy (FURS)

Additionally user can be able

- Precise, in and out movement,
- Remote and precise control of laser fiber,
- Remote control of irrigation flow rate,
Great Interest:
Prizes:

- In Turkish Technology Contest the robot has awarded as first prize.
- Best Scientific Invention Prize.
AUA 2015 New Orleans
Congress: WCE 2013 New Orleans

Robotic flexible Ureteroscopy
The Turkish Robot

Prof. Dr. med. Jens Rassweiler
Department of Urology Heilbronn
University of Heidelberg, Germany

Prof. Dr. Remzi Saglam
Department of Urology Medicana International Hospital
Ankara, Turkey
First live surgery of Avicenna robot performed in Karolinska University Hospital
Live Surgeries: ERUS2014 Amsterdam

AUA Segura Qatar 2015 Doha
Live Surgeries: IAE2015 Milano

8th Int Course on FlexURS 2015Rome
Avicenna Roboflex has been installed

- Medicana International Hospital in Ankara–Turkey
  - Remzi Saglam
- SLK Kliniken in Heilbronn–Germany
  - Jens Rassweiler
- Tenon Hospital in Paris–France
  - Olivier Traxer
- Sheikh Khalifa General Hospital – UAQ, U.A.E
  - AbdulQadir Al–Zarouni and Yasser Farahat
- Sanador Hospital in Bucharest–Romania
  - Petrisor Geavlette
All Brands and Models of fURS are Available

- The new interchangeable flexible ureteroscope holder
The breaking mechanism of Holmium YAG Laser:

- It is not the burn or explosion effect of stone
- High absorption of water for 2100nm wavelength is important
The breaking mechanism is the same as ESWL: Rapid vaporization → Cavitation effect

- The distance between laser fiber and stone is very important
- The precise control of laser fiber to compensate the shortening due to melting and deflection movement is necessary
- Remotely adjustment of tip of laser fiber
Foot pedals of Holmium Laser and Fluoroscopy devices can be control from right and left pedals of Control Unit respectively. That allows safety for Laser shooting to protect flexible uretroscope.
High Precision Control of Deflection

Precision of Thumb Wheel control can be configured from SETUP menu. So fast (Low Res) or slow (High Res) control can be used for better deflection.
Image Processing and Automatic Pilot

Image processing from video signal or picture is applied for diagnosis.

- Edge enhancement, pattern recognition, object recognition
- Precisely control of deflection, rotation and in/out movement by computer inside the determined boundaries
- Evaluation of respiration

Precisely Painting Technique
Image Processing and Automatic Pilot

Image processing of video and computer measurements will be overlayed.

- Better realization
- No need to look to separate control screen
- Better orientation
Potentials:

- Telemedicine
  - Cabled
  - Wireless
  - LAN/WAN
  - Internet
- Communication
We made a multicentric clinical study, and published the results of the 81 patients treated by 7 experts.
## Clinical results of the robot-assisted flexible ureteroscopy

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value</th>
<th>Range</th>
<th>SD</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment time, min</td>
<td>74</td>
<td>40–182</td>
<td>31.8</td>
<td>Inclusive access sheath and DJ stent</td>
</tr>
<tr>
<td>Time docking robot, s</td>
<td>59.6</td>
<td>35–124</td>
<td>45</td>
<td>46 s after 42 cases</td>
</tr>
<tr>
<td>Time to visualize stone, min</td>
<td>3.7</td>
<td>2–8</td>
<td>1.4</td>
<td>Including complete inspection of collecting system</td>
</tr>
<tr>
<td>Fragmentation time, min</td>
<td>45</td>
<td>18–115</td>
<td>21.7</td>
<td>Depending on stone size</td>
</tr>
<tr>
<td><strong>Fragmentation speed, mm³/min</strong></td>
<td><strong>29.1</strong></td>
<td><strong>18–46</strong></td>
<td><strong>6.1</strong></td>
<td>Increasing to 32.7 mm³/min after 42 cases</td>
</tr>
<tr>
<td>Console time, min</td>
<td>53</td>
<td>23–135</td>
<td>23.2</td>
<td>Depending on stone size, learning curve</td>
</tr>
<tr>
<td>Complications</td>
<td>1</td>
<td>–</td>
<td>–</td>
<td>Failure of endoscope (case 42), classic FURS not possible; placement of DJ stent</td>
</tr>
<tr>
<td><strong>Comparison of ergonomics, score</strong></td>
<td><strong>Classic FURS</strong></td>
<td><strong>31.3</strong></td>
<td><strong>16–40</strong></td>
<td>Based on last 10 cases performed by each surgeon at own institution</td>
</tr>
<tr>
<td><strong>Robotic FURS</strong></td>
<td>5.6</td>
<td>3–10</td>
<td>2.4</td>
<td>Based on immediate evaluation</td>
</tr>
<tr>
<td>Re-treatment</td>
<td>2</td>
<td>–</td>
<td>–</td>
<td>Classic FURS</td>
</tr>
<tr>
<td>Nonfunctioning of robot</td>
<td>None</td>
<td>–</td>
<td>–</td>
<td></td>
</tr>
<tr>
<td>Stone-free at 3 mo</td>
<td>65 (80%)</td>
<td>–</td>
<td>–</td>
<td>16 patients (20%) with clinically insignificant residual fragments</td>
</tr>
</tbody>
</table>

FURS = flexible ureteroscopy; SD = standard deviation.
SAFETY AND EFFECTIVITY OF ROBOFLEX AVICENNA, THE NEW ROBOT FOR FLEXIBLE URETEROSCOPY.

INTRODUCTION AND OBJECTIVES

Flexible ureterorenoscopy (FURS) represents a technically challenging procedure requiring specific endourologic skills. Based on preclinical studies, we present early clinical experience with treatments performed by 7 different experienced endourologists (IDEAL phase 2) who have used the Roboflex Avicenna device (ELMED, Turkey) developed for remote controlled flexible ureteroscopy. We searched the safety and effectiveness of this new device.

Table 1. Patients data

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value</th>
<th>Range</th>
<th>SDV</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male/female</td>
<td>50/25</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Single/polyp</td>
<td>20/12</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Stone size (mm)</td>
<td>13</td>
<td>5-30</td>
<td>5.3</td>
<td>Same of length</td>
</tr>
<tr>
<td>Stone volume (mm³)</td>
<td>1296</td>
<td>432-3100</td>
<td>544</td>
<td>CT-Based</td>
</tr>
</tbody>
</table>

Table 2. Results of clinical study

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Value</th>
<th>Range</th>
<th>SDV</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment Time (min)</td>
<td>48-142</td>
<td></td>
<td></td>
<td>Inclusive access sheath and 15-mm after 42 cases</td>
</tr>
<tr>
<td>Inserting time (sec)</td>
<td>35-124</td>
<td></td>
<td></td>
<td>Including inspection of collecting system</td>
</tr>
<tr>
<td>Stone localization (mm)</td>
<td>3.7</td>
<td>2-6</td>
<td>1.4</td>
<td></td>
</tr>
<tr>
<td>Fragmentation (mm)</td>
<td>45</td>
<td>14-115</td>
<td>21.7</td>
<td>Depending on stone size</td>
</tr>
<tr>
<td>Fragmentation speed (mm/min)</td>
<td>25</td>
<td>19-46</td>
<td>16.1</td>
<td>Increasing to 55 mm/min after 42 cases</td>
</tr>
<tr>
<td>Console time (min)</td>
<td>53</td>
<td>23-135</td>
<td>23.2</td>
<td>Dependent on stone size and learning curve Failure of endoscopy (case 42)</td>
</tr>
<tr>
<td>Complications</td>
<td>1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Stone-free at 3 months</td>
<td>63 (97%)</td>
<td>-</td>
<td></td>
<td>100% (p&lt;0.05) CNJ</td>
</tr>
</tbody>
</table>

METHODS

After Ethical approval, a total 81 patients (mean age 42, range 6-68) were treated. We used Roboflex Avicenna. After locking the flexible endoscope, all functions could be controlled remotely from the console, out of the radiation exposure field, without wearing a lead apron. Operation time and pulverisation time were recorded. After one and three months from the operation we checked the residual fragments by KUB and ultrasonography. We requested from all 7 surgeons to fill out the validated questionnaire.

RESULTS

All patients had renal calculi with a mean CT calculated volume of 1296 mm³. Access sheath was used in 72 of patients. Mean time to dock the robot was 59.6(35-124) seconds; mean fragmentation time was 46(15-118) minutes corresponding to a mean fragmentation speed of 29.1(18-46) mm/min. Mean console time was 53(23-135) minutes. Complete stone disintegration was accomplished in 79 patients (96%). After 3 months 65 patients (80%) were stone-free. Robotic FURS showed significantly better ergonomics.

CONCLUSIONS

Robotic-assisted flexible ureterorenoscopy using the Avicenna Roboflex provides a suitable, safe and effective platform for FURS with significant improvement of ergonomics. Future studies will also evaluate the impact of the device on clinical outcome of FURS.
Experts can use the Roboflex after an explanation and watching 1 or two cases.

The trainees can learn and reach a good level after 4 trial on the kidney model.

**Table 2. Time to fragmentation of experts and trainees groups**

<table>
<thead>
<tr>
<th>Experts Group</th>
<th>Trainees Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expert 1</td>
<td>Trainees 1</td>
</tr>
<tr>
<td>Expert 2</td>
<td>Trainees 2</td>
</tr>
<tr>
<td>Expert 3</td>
<td>Trainees 3</td>
</tr>
<tr>
<td>Expert 4</td>
<td>Trainees 4</td>
</tr>
<tr>
<td>Expert 5</td>
<td>Trainees 5</td>
</tr>
<tr>
<td>Average</td>
<td>Average</td>
</tr>
<tr>
<td>Manuel 1</td>
<td>24</td>
</tr>
<tr>
<td>Manuel 2</td>
<td>18</td>
</tr>
<tr>
<td>Manuel 3</td>
<td>23</td>
</tr>
<tr>
<td>Manuel 4</td>
<td>22</td>
</tr>
<tr>
<td>Manuel 5</td>
<td>20</td>
</tr>
<tr>
<td>Robotic 1</td>
<td>32</td>
</tr>
<tr>
<td>Robotic 2</td>
<td>31</td>
</tr>
<tr>
<td>Robotic 3</td>
<td>27</td>
</tr>
<tr>
<td>Robotic 4</td>
<td>27</td>
</tr>
<tr>
<td>Robotic 5</td>
<td>27</td>
</tr>
</tbody>
</table>

**CONCLUSIONS**

1. The mean robotic time for experts was longer than manual.
2. The mean robotic time for the trainees was SHORTER than the manual.