Robot-assisted percutaneous scaphoid screw placement

Bo LIU (刘波)
MD, FRCS
Consultant Hand Surgeon
Beijing Ji Shui Tan Hospital
Beijing, China
Almost every “expert” think himself/herself is a “magical shooter”

Easy task!

Quick procedure!

Always true?
Complication rate of percutaneous fixation of scaphoid fracture is as high as 30%

BD Bushnell, JHS, 2007
... a seasoned hand surgeon can struggle to accurately place a percutaneous screw safely within the scaphoid.

A not uncommon example:

Multiple attempts tried and 106 fluoroscopy images taken to achieve an accurate placement of a percutaneous screw for a single patient.
Why sometime percutaneous fixation is not “a piece of cake”? 

1. The anatomy of scaphoid bone

- A really tiny bone
- The average thickness over the waist is around 1cm
- Tortuous shape
Given a screw with a radius of 1.7 mm ($R$), a cortical bone thickness of 0.35 mm ($C$), and an 0.25-mm safety margin ($S$), the safety zone was 2.3 mm from the outer bone surface in all directions.
A 2mm error may lead to disaster...
2. You can not really see it!

Circus Knife Throwing without seeing anything
3. It’s moving!
How to make sure the good luck always go around with you?
Navigation assisted scaphoid percutaneous fixation
--cadaveric study
Bo Liu & SL Chen, Beijing Ji Shui Tan hospital, 2013

- Scaphoid Navigated Aiming Device
- Integrated patient tracker
- Control the micro movement
Navigation assisted scaphoid percutaneous fixation

--Accuracy validated by cadaveric study

Bo Liu & SL Chen, Beijing Ji Shui Tan hospital, 2013
Navigation assisted scaphoid percutaneous fixation
--clinical application
Bo Liu & SL Chen, Beijing Ji Shui Tan hospital, 2014

Successful clinical outcomes achieved from 2014,
Bo Liu & SL Chen, Beijing Ji Shui Tan hospital
Problem remains:
1. Error may occur due to the micro movement of the surgeon’s hand
2. Manual adjustment of the aiming device takes time
Robot assisted surgery: new solution
The robots

Soft tissue (Da vinci)

3D navigated robotic “hand” for bone tissue (Tinavi, Beijing)
Robot-assisted microsurgery
--vascularized fibular grafting for AVN femoral head
Dr. Shanlin CHEN, Beijing Ji Shui Tan Hospital, from 2016
Challenges present from big bones to small bones...
Robot assisted percutaneous scaphoid fixation
--cadaveric study
Bo Liu & SL Chen, Beijing Ji Shui Tan hospital, from 2016
Robot assisted percutaneous scaphoid fixation
--Accuracy validated by cadaveric study
Bo Liu, Beijing Ji Shui Tan hospital, from 2016
Robot assisted percutaneous scaphoid fixation
Clinical study from 2018, Bo Liu, Beijing Ji Shui Tan hospital

- 3D fluoroscopy unit (ISO-C3D, Siemens, Erlangen, Germany)
- TiRobot--robotic navigation system (TINAVI Medical Technologies, Beijing, China)
- The optical tracking system-- is made up of an infrared stereo camera and two reference frames, the patient reference and the robotic reference
Robot assisted percutaneous scaphoid fixation
Clinical study from 2018, Bo Liu, Beijing Ji Shui Tan hospital

- 3D fluoroscopy unit (ISO-C3D, Siemens, Erlangen, Germany)
- TiRobot -- robotic navigation system (TINAVI Medical Technologies, Beijing, China)
- The optical tracking system -- is made up of an infrared stereo camera and two reference frames, the patient reference and the robotic reference frame
- TiRobot system
  - A stereotactic robotic arm with 6 degrees of freedom
- A stereotactic robotic arm with 6 degrees of freedom
- An optical tracking device (Eyes)

3D fluoroscopy unit (ISO-C3D, Siemens, Erlangen, Germany)
- TiRobot--robotic navigation system (TINAVID Medical Technologies, Beijing, China)
- The optical tracking system-- is made up of an infrared stereo camera and two reference frames, the patient reference and the robotic reference
Robot assisted percutaneous scaphoid fixation
Clinical study from 2018, Bo Liu, Beijing Ji Shui Tan hospital

- 3D fluoroscopy unit (ISO-C3D, Siemens, Erlangen, Germany)
- TiRobot--robotic navigation system (TINA VI Medical Technologies, Beijing, China)
- The optical tracking system-- is made up of an infrared stereo camera and two reference frames, the patient reference and the robotic reference

TiRobot system
- A stereotactic robotic arm with 6 degrees of freedom
- An optical tracking device
- A 3D fluoroscopy unit (ISO-C3D)
Robot assisted percutaneous scaphoid fixation
Clinical study from 2018, Bo Liu, Beijing Ji Shui Tan hospital

- 3D fluoroscopy unit (ISO-C3D, Siemens, Erlangen, Germany)
- TiRobot robotic navigation system (TINAVI Medical Technologies, Beijing, China)
- The optical tracking system is made up of an infrared stereo camera and two reference frames, the patient reference and the robotic reference

TiRobot system
- A stereotactic robotic arm with 6 degrees of freedom
- An optical tracking device
- A 3D fluoroscopy unit (ISO-C3D)
- A surgical planning workstation
- The simulated entry point and trajectory of the screws are selected by the surgeon.
- The selected trajectory of the screw is checked in 360° continuous sagittal, axial and coronal planes, to confirm the optimal 3D position of the screw.
The TiRobot is be able to simulate different screw lengths as well, with an accuracy of less than 1mm.
Robot assisted percutaneous scaphoid fixation
Clinical study from 2018, Bo Liu, MD. Beijing Ji Shui Tan hospital

Just press the button and the robot will do the job for you!
Robot assisted percutaneous scaphoid fixation
Clinical study from 2018, Bo Liu, MD. Beijing Ji Shui Tan hospital

Very relaxed surgeon’s hand
24 yrs young gentleman, acute scaphoid fracture

Single attempt, one shoot
Operation time (include set up): 36 min
Between January and September 2018

10 patients underwent robot assisted percutaneous scaphoid fixation

All fractures were undisplaced in the scaphoid waist
The mean total operative time was **40 min**
- mean set-up time of **18 min** (from patient and equipment positioning and performing the registration scan)
- Mean surgical time of **22 min** (from performing the intraoperative planning on the TiRobot workstation to skin closure)

In all patients, only a **single guide wire insertion attempt** was needed
Outcomes

- Postoperative x-ray and CT imaging showed that the implanted screw in each patient was within the central zone of the scaphoid, corresponding to the intraoperative planning from the workstation.

- The screw length used in each patient matched exactly with the planned length.
Robot-assisted percutaneous scaphoid fracture fixation: a report of ten patients

Bo Liu¹, Feiran Wu², Shanlin Chen¹, Xiuyuan Jiang³ and Wei Tian⁴
Probably we should find something more interesting for surgeon’s hand during the operation in the future...
Welcome to Beijing, 4~5 Sep, 2020
9th Beijing International Wrist Course & Wrist Arthroscopy Workshop

Thank you my friends!
Robot-assisted percutaneous scaphoid screw placement

Bo LIU (刘波)
MD, FRCS
Consultant Hand Surgeon
Beijing Ji Shui Tan Hospital
Beijing, China