Computer Assisted Navigation In Surgery Of The Calcaneus

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Background

Intraoperative imaging has changed the field of orthopaedic surgery. It has led to increased accuracy and reduction of complication particularly with regards to minimally invasive surgery. Newer technologies continue to evolve, such as 3-Dimensional Computed Tomography (3-D CT), which provides real-time imaging of surgical site anatomy and allows for higher accuracy of the surgical steps for each specific case as planned preoperatively (fracture reduction, planning of osteotomy, placing and calculating implant sizes), while avoiding risk to neighboring critical structures.

Objectives

The objective is to illustrate the value of navigated surgery especially in an anatomically challenging location, as well as defining specific technical protocols.

Materials & Methods

40 consecutive computer navigated calcaneal surgeries were preformed for a verity of conditions from January 2015 to October 2017. Two common procedures were selected, minimally invasive reduction and fixation of a calcaneal fracture and correction of calcaneal malunion. The illustrative cases demonstrate the technical aspects of and the use of intraoperative imaging and navigation.

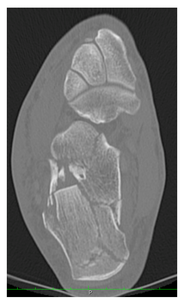
Case 1: Calcaneal Fracture: Minimally Invasive Osteosynthesis

Clinical history

Calcaneus tongue-type fracture in a young gymnastic patient due to a fall from a height in practice

Surgical challenges

1. Fracture reduction
2. Anatomy restoration
3. Screw fixation



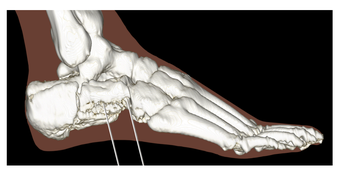
Navigation

1. Navigating the Schanz pin
2. Identification of the entry points
3. Visualization of the trajectory
4. Calculation of the screw length

Surgical tactic

Step 1: Reference frame fixation

Patient is placed in the lateral decubitus position.
Two 1.6mm K-wires are inserted through the base of reference frame and fixed to the plantar lateral aspect of the calcaneus.



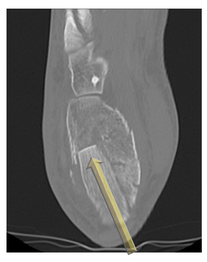
K-wires fixation

Step 2: CT scan acquisition

A fluoroscopic image is obtained prior to the CT scan to ensure satisfactory position and fixation of the reference frame.

Step 3: Navigating the Schanz pin

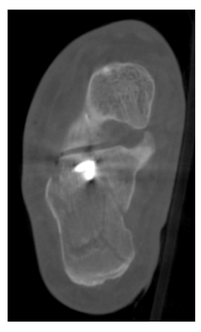
Navigation of Schanz pin on the power drill allows for accurate entry point selection and its placement in the center of the tongue fragment. This entry point should be at the tip of the calcaneal tuberosity just below the dorsal cortex.

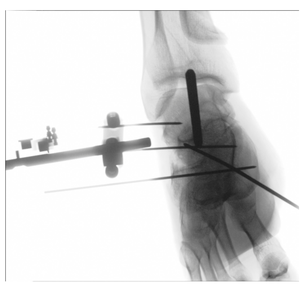


Schanz pin entry point

Step 4: Fracture reduction

Reduction maneuver of the tongue fragment with use of the Schanz pin as a joystick.
The fracture is preliminarily fixed by 1.6mm K-wires. Intraoperative CT scan is then used to assess the fracture reduction.





Step 5: Navigating the screws

Navigating the screws as they are placed allows for:

- Exact calculation of the length and trajectory of each screw
- Avoiding any damage to adjacent joints or neighboring structures on the medial side.

Minimum of three screws are mandatory to secure the posterior facet. The screw of the posterior facet should be inserted as a lag screw to the sustentaculum tali.
Other screws secure the tongue to the tuberosity in the sagittal plane and additional screws are to be placed as necessary depending on the remaining fracture lines.

Step 6: Postoperative results

Weight-bearing radiographs at one-year show restoration of hindfoot height and normal calcaneal width.
Patient is completely healed and has returned to normal activities and gymnastics.

Case 2: Calcaneus Malunion: Osteotomy of Fracture and Subtalar Fusion

Clinical history

43 year-old manual labourer presents with a malunion in varus and loss of height of the hindfoot 1-year post nonoperative treatment of a joint depression calcaneal fracture

Surgical challenges

The challenge in this case is to perform the osteotomy **through the primary fracture line** in order to regain hindfoot height and alignment.

Navigation

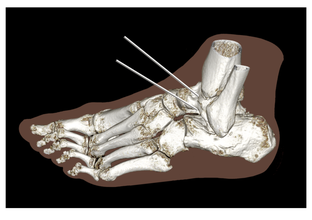
The following were navigated:

1. The osteotome and calcaneus osteotomy line 2. The drill bit 3.The position and length of the sub-talar arthrodesis screws

Surgical tactic

Step 1: Reference frame fixation

Patient is in the lateral decubitus position.
Two 1.6mm K-wires inserted through the base of the reference frame and fixed to the neck of the talus so as to avoid any undue motion.



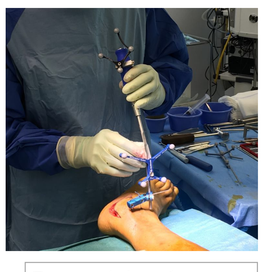
Step 2: CT scan acquisition

A fluoroscopic image is obtained prior to the CT scan to ensure satisfactory position and fixation of the reference frame.

Step 3: Instrument calibration

The osteotome is calibrated using the adapter. Calibration of the power drill on the reference frame is followed by verification of navigation accuracy and identification of the entry points for the subtalar arthrodesis screws.

Recognizing the pointer on the reference frame



Recognizing the osteotome on the reference frame

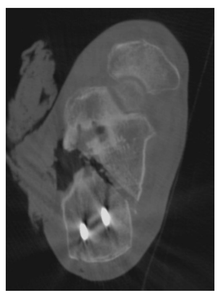
Recognizing the entry point of the osteotome

Navigated osteotomy through the fracture line

Step 4: Navigating the osteotome

Navigation of the osteotome allows for accurate entry point selection and exact re-creation of the primary fracture line. Intraoperative CT scan is obtained to ensure a satisfactory calcaneal osteotomy.

Navigation trajectory on the CT scan (Blue line: entry point; Yellow line: trajectory and length);



Axial image of the osteotomy

Step 5: Subtalar arthrodesis

The subtalar joint is prepared and filled with cancellous bone graft taken from the ipsilateral distal tibia.

Step 6: Navigating the screws

Navigating the screws as they are placed allows for optimal results. A minimum of two screws are mandatory to secure the osteotomy and the arthrodesis sites.

Step 7: Postoperative results

The postoperative standard radiographs show the restoration of hindfoot height and normal calcaneus width. Patient is fully healed and returned to normal activities of daily living and work.

Conclusions

In our experience, a good and thorough planning of the computer assisted navigated surgery allows for a smooth running operation and optimization of the outcome while minimizing the risks for the patient. These two illustrative cases together with our extended experience in 3-D navigated surgery of the calcaneus support routine use of this promising technology.

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