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Computer Assisted Surgery and Navigation: Where Do We Stand in the Field of Foot, Ankle and Leg Surgery ?

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Abstract

- Computer-assisted orthopaedic surgery (CAOS) is a real-time navigation guidance that supports surgeons during orthopaedic cases. The use of navigation guidance helps to increase precision, is less invasive and helps to achieve the surgical goal as planned.
- Intraoperative imaging certifies that the initial goal of the surgery has been achieved and if necessary adjusted.
- Surgical indications have largely extended to a variety of fields from trauma, delayed reconstruction, congenital abnormalities and even to foreign body extraction.
- CAOS helps to reduce radiation exposure to surgeons and staff when performing minimally invasive surgery compared to conventional fluoroscopy techniques.
- This paper explores the fields of applications of real time navigation and computer assisted surgery for foot and ankle conditions.

Calcaneonavicular coalition fusion

Congenital coalition of the calcaneonavicular (CN) joint (Figure 1a,b). Surgical intervention indications are symptomatic foot with decreased quality of life and the condition being refractory to non-operative treatment for over 2 years. Surgical challenges to be aware of and prepared for, such as fusion site débridement and grafting, optimal selection of the appropriate entry point, trajectory and length of the screw and as well as to avoid having the screw in an adjacent joint (e.g., talonavicular).

The reference frame is facing upwards and laterally where the camera is positioned. Intraoperative CBCT scan is acquired after ensuring satisfactory position and fixation of the reference frame (Figure 1c). The universal pointer and the power drill are calibrated, the reamer is used to break the coalition and to prepare the CN fusion site. A cancellous bone graft is obtained. The guide wire is navigated and a cannulated partially threaded screw is placed in a minimal invasive way under continuous visualization of the trajectory (Figure 1d,e,f).

Simulated weight-bearing standard radiographs (Figure 1g,h).

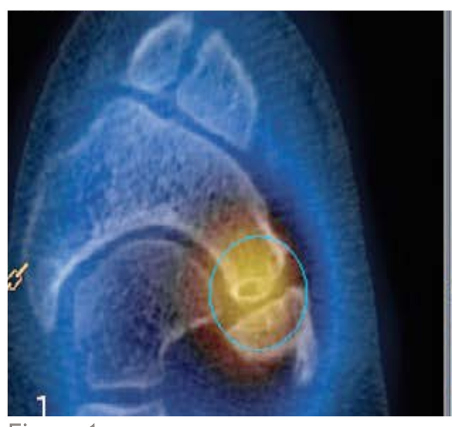
Figure 1a


Figure 1b


Figure 1c


Figure 1d


Figure 1e


Figure 1f


Figure 1g


Figure 1h

Midfoot fusion with bolts for Charcot foot

Advanced midfoot neuroarthropathy (Charcot foot) with fragmentation of the navicular. Previous operations in another medical facility resulted in nonunions (subtalar and talonavicular joints). Surgical challenges are extremely important with poor-quality bone and multiple nonunion sites, medial arch collapse, and the placement of an intramedullary implant (midfoot fusion bolt).

Hardware is removed, fragmentation of the navicular is addressed and the subtalar joint is débrided (Figure 2a). The first cuneometatarsal joint is prepared for fusion. The foot is realigned in the three planes. Multiple temporary K-wires are inserted in order to lock the plantigrade position.

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The 8 x 1 cm cortical strut is harvested from the ipsilateral proximal tibia and placed in a carved split along the medial aspect of the foot medial column (Figure 2b,c,d). The cannulated bolt wire is calibrated using the adapter and the entry point at the level of the first metatarsal head is identified by the projected navigation line that passes through the first metatarsal shaft longitudinal axis, the centre of the talar head and the centre of the talar dome sagittal radius (a straight Meary line). The bolt is inserted after drilling along the bolt wire. A long and thick medial column plate is used to augment the strength of the construct.

Standard radiographs show restoration of the foot medial arch (Figure 2e,f).


Figure 2a


Figure 2b


Figure 2c


Figure 2d


Figure 2e


Figure 2f

Tibia post-surgical malrotation: derotation osteotomy

Tibia post-surgical malrotation at six months post lower third tibial shaft fracture and intramedullary (IM) nail fixation. Clinical examination revealed excess of external rotation of 26° of the distal tibia in relation to the proximal tibia when compared to the contralateral leg, supported by a comparative CT scan (Figure 3a,b,c).

Surgical challenges 1. Recreate the original fracture line 2. Exact internal derotation.

A percutaneous burr is used to achieve a minimal invasive osteotomy of the fibula. The IM nail is kept in place while the distal locking bolts are removed. An anteromedial approach is used over the original fracture site. A chisel is used to recreate the transverse fracture around the IM nail. Intraoperative CBCT scan is acquired after ensuring satisfactory position and fixation of the reference frame (Figure 3d).

A 2.5 mm K-wire is calibrated, and then carefully fixed to the distal tibia at the mid-malleolar distance (Figure 3d). A tracker is then fixed on the K-wire allowing for tracking of the distal tibial axis when rotating. The navigation program is used to create a 3D illustration showing the angle of rotation needed to achieve the desired axis correction (Figure 3e). When the correction is obtained, the osteotomy site is then secured by a two-hole 1/3 tubular plate and the IM nail is locked distally.

Post-operative standard radiographs show satisfactory coronal alignment (Figure 3f,g). Clinical alignment is identical to the contralateral side.

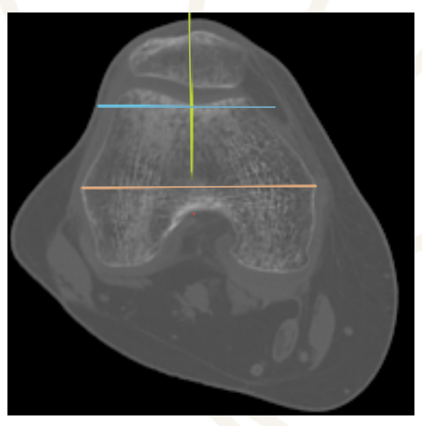
Figure 3a

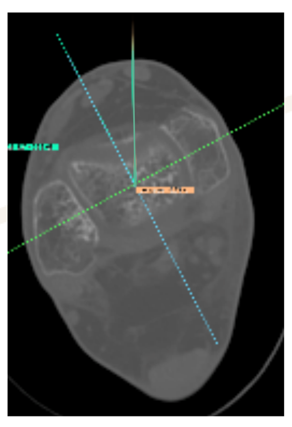
Figure 3b


Figure 3c


Figure 3d

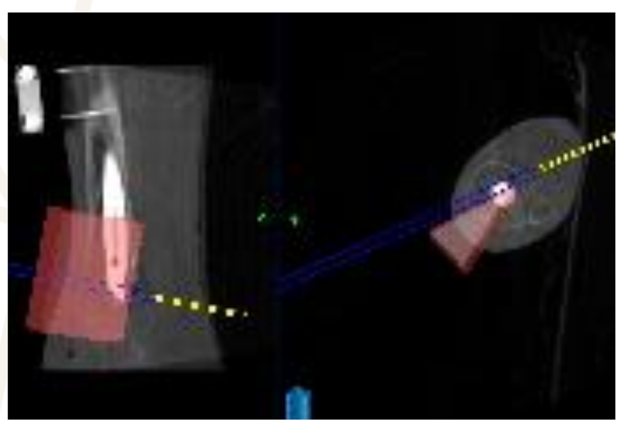
Figure 3e


Figure 3f


Figure 3g

Conclusion

CAOS with intraoperative navigation allows for more precise surgery in many lower leg indications, while permitting a less invasive approach. In addition, it accurately confirms that the preoperative surgical plans have been achieved intraoperatively. With such technology presently available it supports our belief that this represents the standard of care.

In our experience a well-trained team can perform such surgeries and achieve maximized results. This leads us to confirm that the quality achieved balances favorably with the financial investment and training.

* Scan the QR Code in order to download the book «Navigated Foot & Ankle Surgery»