Computerized navigation for length and rotation control in femoral fractures: a preliminary clinical study

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Introduction: Nailing of femoral fracture is considered to be a very successful procedure with high healing rates[1]. However, it is not devoid of complications. As more high energy shaft fractures are being nailed, malunions are likely to occur, with malrotation deformity being the most prevailing one[2]. Recent laboratory and cadaver studies have demonstrated the efficacy of computer navigation systems in controlling femoral rotation during femoral shaft fracture fixation[3]. However, clinical data to support these results is still lacking. The aim of the current study is to report and evaluate the clinical results of navigated femoral fracture fixation done on thirteen consecutive patients.

Patients & Methods: Prospective, IRB approved cohort study done in an academic level I trauma center. Thirteen skeletally mature patients met the inclusion criteria of the study. These included: traumatic femoral shaft fracture or fracture mal/non-union. Exclusion criteria were ipsilateral femoral neck fracture, existence of a prosthetic joint in either lower extremity, polytrauma precluding prolonged surgery, and extension of the fracture into the knee joint.

All surgeries but one were performed by a single surgeon. Ten cases were acute femoral shaft fracture treated with an intramedullary nails. Two patients were treated with Less Invasive Stabilization System (LISS, S ynthes): One for an acute fracture through a benign osteolytic lesion and one as a revision of a rotational malreduction. One patient was treated with an open exchange nailing for a femoral shaft nonunion. Ten of the nails were antegrade nails, out of which eight were piriformis fossa entry nails and two trochanteric entry nails. Two nails were retrograde femoral nails. All antegrade nails were inserted with the patient positioned on a fracture table and the rest of the cases using a radiolucent table.

Computerized navigation: The BrainLAB Trauma 3.0 BetaTM version was used the navigation platform in all cases. At the beginning of each case, after induction of anesthesia, a noninvasive optical tracker was placed on the uninjured thigh using a Velcro strap. Tracked anteroposterior (AP) and lateral images of the proximal and distal femur were obtained.

A handheld tracker placed in the vicinity of a C-arm fluoroscope (X-SpotTM) was used to track the images along with the noninvasive tracking. The resultant images were marked by the surgeon for the center of the femoral head, the posterior tip of the greater trochanter, the most posterior part of the femoral condyles on a perfect lateral image of the knee, and the center of the knee. The software automatically calculated the axial rotation angle between the proximal and distal femoral landmarks as well as the femoral length.

The injured extremity was then prepped and draped in a standard sterile fashion. The femoral nailing procedure was then commenced in a standard surgical fashion according to surgeon preference. After nail insertion and prior to any nail interlocking, trackers were placed in both proximal and distal injured femur; in antegrade piriformis fossa and retrograde nails- two 3mm Shanz screws were placed in the greater trochanter, while in trochanteric-entry nails a single 5mm Shanz screw was placed in A to P direction in the lesser trochanter. Two distal 3mm Shanz screws were placed in the medial femoral condyle. The process of imaging acquisition and landmarking was identical to the one described above for the uninjured extremity. At this point, the tracking camera of the navigation system recorded the length and rotation of the injured, nailed extremity (figure 1). The rotation and length were corrected, if possible (in two cases, the extremity was kept shortened due to excessive comminution and bone loss). After obtaining satisfactory alignment (<5 degrees of rotational difference and less than 1cm for length differences) interlocking screws were placed in both proximal and distal ends of the nail while maintaining reduction.

Postoperatively, a CT scanogram of both femora was obtained using an abbreviated protocol. Length of both femora was measured as the length between the femoral heads and the intercondylar notch, while axial rotation was measured as the angle between the largest portion of the visible femoral neck and the posterior femoral condyles using a PACS system, with two measurements performed per each case.

Since it was already established that the rotation angle values between fluoroscopic navigation and CT do not match, the differences in rotation angles between the uninjured and injured extremities, rather than the absolute angle values, were used for evaluating the results.

Results: Rotational alignemnt differences between the treated and non-treated femora as measured by the CT scanogram averaged 5.2° (range 0-10°) with no case exceeding 10° of rotational difference. The average rotational error recorded and observed in the navigation system during surgery was 2.9 (range 0-9°). The difference between these two sets of measurements was statistically significant ($p < 0.01$), albeit being small and of no clinical significance (2.1 degrees). The average length difference between the two extremities, as measured by the CT was 7mm (range 0-21) as in two cases shortening was observed during surgery and accepted due to comminution. However the differences between the observed length differneces between navigation and CT were not statistically significant.

Conclusions: Use of computerized navigation in femoral shaft fractures has the potential of significantly improving the results of femoral shaft fixation in closed methods in terms of rotational alignment. In none of the cases performed in our study, a clinically significant rotational misalignment occurred despite fracture comminution in many cases. Length measurement was accurate in the navigation system as compared to CT scanogram. A larger series of cases with a control groups is needed to further establish these results.

References

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