# Causative Factors for Femoral Pin Track Fractures in Navigated Total Knee Arthroplasty

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## ABSTRACT

This retrospective radiographic analysis of 57 patients (62 knees) examined two possible factors involved in pin tract fractures of the femur due to navigated total knee arthroplasty (TKA): the angle of the tracker pin with respect to the lateral femoral cortex, and the distance between the tracker pin and the lateral joint line. Our findings demonstrate a relationship between postoperative pin tract induced stress fractures (3 patients), with pin tract angles exceeding 15°. Pin placement at a site more than 10cm from the lateral joint line, did not show any significant association with risk of fracture. These findings lead to enhanced understanding of the causative factors underlying pin track femoral fractures in TKAs.

Key Words:
*Computer Assisted Navigation, Total Knee Arthroplasty, Stress Fracture*

## INTRODUCTION

Computer assisted navigation in TKA has been gaining popularity due to validation of its increased accuracy for implantation of femoral and tibial components [1-3]. Most navigation systems require femoral and tibial pin insertion for placement of trackers. Unfortunately, the resultant bony defects act as stressors. Stress fractures involving previous pin site tracts in computer assisted TKAs have been reported with increasing frequency and various reasons have been put forward regarding the cause(s) of these fractures, without any real consensus [4-8]. The purpose of this study was to identify and analyse possible factors contributing to pin tract related fractures of the femur.

## MATERIALS AND METHODS

We retrospectively reviewed the radiographs of consecutive patients who underwent computer assisted posterior stabilized primary total knee replacements (Scorpio NRG, Stryker) in our institution from January 2007 to December 2007. All the subject surgeries were performed by two of the institution's senior arthroplasty surgeons with the same protocol of tracker pin insertion utilized in each instance.

The placements of the 2 femur anchoring pins were made via separate, percutaneous stab incisions. These 3.0 mm threaded pins are self-drilling and self-tapping. We use the same instrument model (Stryker) in all cases, a wall mounted pneumatic drill system. The first (distal) pin is inserted bicortically in a medial to lateral direction, at a distance of approximately two finger breadths above the superior pole of the patella, angled 45 degrees to the sagittal plane of the femur. The jig for the tracker (OrthoLock, Stryker) is then placed over the distal pin. The second hole in the jig, which lies 2.5 cm proximal to the first, guides the insertion of the second pin, i.e., bicortically, at 30 degrees to the sagittal plane of the femur. Tibial pins are placed in a similar fashion in the anteromedial tibial diaphysis at a distance of four fingerbreadths, distal to the tibial tubercle. The tibial proximal pin is inserted first, followed by the distal pin in a similar fashion to the femur. A maximum of 2 attempts of pin placement are allow for each pin placement. The tracker is then attached, anatomical landmarks are recorded, and the TKA procedure is then completed. At the end of the procedure, all pins are removed with a power driver. Post-operatively, continuous passive motion exercises are started at Day 2. Full weight bearing is allowed on Day 3 with physiotherapist supervision. Subsequent follow-ups evaluations are conducted at fixed intervals, i.e., 2 weeks, 1 month, 3 months, and 6 months. Postoperatively, all patients achieved coronal varus and valgus angle of ± 3°

All radiographs were reviewed by two independent researchers. Two possible causative factors for fracture(s) were analysed (1) The angle made by the pin tract, with the lateral wall of the femur in the AP radiograph was analysed as to the oblique nature of the distal femoral pin as it penetrates the cortex. (2) The distance from the distal femoral pin to the lateral joint line was analysed (Figure 1).

Statistical analysis was performed utilizing SPSS (Version 14 for Windows), data were analysed using Chi Square test, a p value of 0.05 was chosen.

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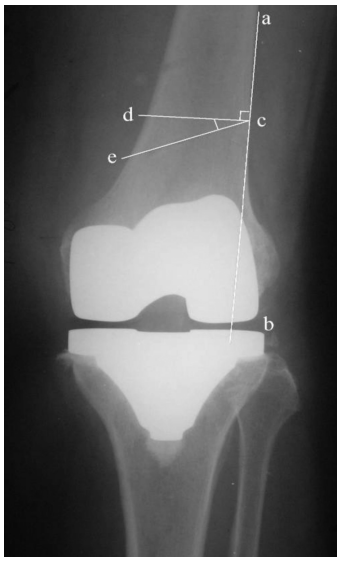


**Fig. 1:** Pin insertion angle is the angle made between the lines CD and CD. AB is the line drawn along lateral cortex of the femur. CD is the line perpendicular to AB. CE is the line connecting the two points made by the distal pin tract.

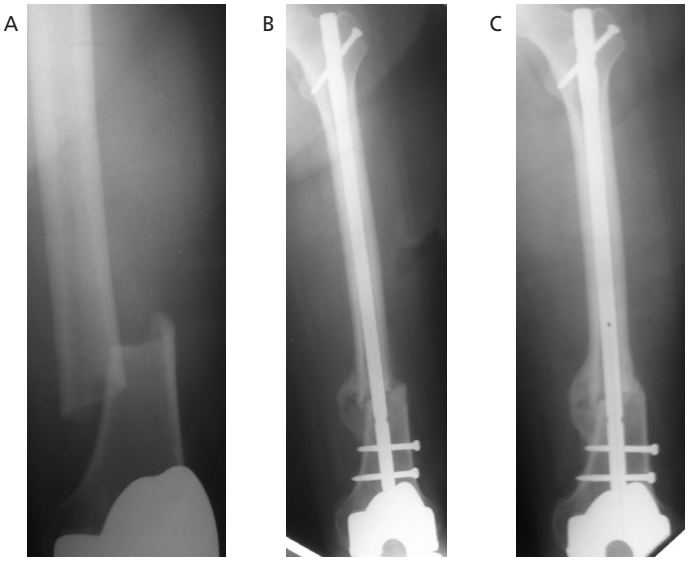


**Fig. 2:** (A) Fracture at the distal pin tract, 7-weeks after a navigated TKA. (B) 6 weeks after an interlocking nail for a pin-tract related fracture. (C) 6 months after an interlocking nail, showing abundant callus formation.

## RESULTS

Four patients were excluded, due to incomplete clinical data. There were a total of 57 patients (48 female, and 9 male), with 62 knees (5 bilateral; a total of 28 right knees and 29 left knees) included in the study. The mean age of study subjects was 65y (range 48-82). All were diagnosed with primary osteoarthritis. The mean pin tract angle was 7° (range 0-25°). Out of the 62 knees, 9 had an angle of >15° and of these, 3 knees had fractures, a statistically significant difference ($p<0.05$) as compared to the remainder of 53 knees with angle of <15°, with no fractures. The three patients who sustained post-operative pin tract induced stress fractures constitute 4.8% of all computer assisted total knee replacement performed.

The mean distance of the distal femoral pin from the lateral joint line was 9.9cm (range 4.6-14.4cm). Of the 62 knees, 31 had a distance of 10cm or more from the distal femoral pin of to the lateral joint line, and of these only 2 knees had fractures; the remaining 31 knees with distance of less than 10cm from the distal femoral pin to the lateral joint line, only 1 had a fracture. There was no significant association of fracture when the pin placement distance exceeded 10cm from the lateral joint line.

Case 1. A 67year old woman with severe osteoarthritis of the left knee presented with a spontaneous fracture at the distal pin tract site, 13.2 cm from the lateral joint, 4 weeks postoperatively. The pin tract insertion angle was 20°. The fracture was subsequently stabilized with an interlocking nail (Russel Taylor nail, Smith & Nephew, Memphis). Bony union was achieved 4 months post-operatively.

Case 2. A 64 year old woman with bilateral knee osteoarthritis presented with a displaced fracture of the right femur, at the distal pin tract site, 11.6 cm from the lateral joint line 7 weeks post-operatively. The pin tract angle was 15°. An interlocking nail (Russel Taylor nail, Smith & Nephew, Memphis) procedure was performed, with union achieved after 6 months. (Figure 2 A, B, C)

Case 3. This patient, presented with persistent left thigh pain postoperatively. Serial x-rays were unremarkable until 6 months post-operatively, when a fracture line appeared at the previous distal femur pin tract site, which was 7.5cm from the lateral joint line. There was periosteal reaction. The pin tract angle was 22°. The patient was treated nonoperatively, i.e., protected weight-bearing, until bony union was achieved 3 months following diagnosis of the fracture.

## DISCUSSION

Numerous published studies cite cortical defects acting as stressors in the bone, but fractures associated with computer-assisted navigation pins are rare. There is no single recommendation regarding the site for femur tracker pins. Various techniques include placing the pins at the metaphyseal / diaphyseal junction, 10 cm proximal to the knee joint, or into the femoral diaphysis, as far proximal as possible [9,10]. Although rare, this complication represents

significant morbidity. A displaced fracture requiring operative fixation may negatively affect overall alignment, indirectly affecting implant survival and final outcome of the TKA. The duration required for fracture healing also disrupts the rehabilitation process. There is also the financial burden of additional surgery and hospitalisation secondary to these fractures.

Various causes have been postulated for these types of fractures. Ossendorf et al suggested that repeated attempts at pin placements increase the risk of stress fracture. He advocated unicortical pins, placed in an orthogonal fashion to avoid stress fractures [1]. Jung et al believed that these stress fracture are due to a misplaced fixation pin placed trans-cortically [2]. Li *et al* found that 3 bicortically drilled holes decreases the strength of the femoral structure. Instead, he recommended small diameter anchoring pins or screws, and advised avoidance of eccentric drilling, especially in an overweight patients.

We postulate that biomechanically if an oblique pin tract is made (angle $\geq 15°$), the tract may travel or involve longer distances of bone as compared to transverse insertion, thus causing increased stress in the bone and predisposing to fracture. We currently insert the pin as perpendicular as possible to the cortex and we also advocate bicortical distal pin placement, at the mainly cancellous site of the supracondylar metaphyseal region of the distal femur, at an angle of 90 degrees to the sagittal plane of the femur. We prefer unicortical pins for the second proximal pin as a safety precaution for the femur and tibia. Placement of the pins from a medial to lateral direction at about a 90-degree angle to the sagittal plane also avoids breaching the anterior cortex of the femur, which represents the tension side of the femur.

Limitations of this study include small sample size, and the fact that we investigated only two of several possible factors that may contribute to the risk of fracture (such as: osteoporosis, gender, obesity, height, weight and underlying systemic illness). Although of the number of cases reported herein is not large, we note that since applying these recommendations in our clinical orthopaedic practice, there have not been any pin tract related stress fractures in the subsequent 200 cases performed.

## CONCLUSION

Navigated TKAs are not without complications. The incidence of fracture at pin insertion sites can be reduced significantly if we understand the contributing factors. There is association of femur fracture when insertion of the distal femoral pin angle exceeds a 15° angle (from the lateral wall of the femur). However this problem does not seem to be affected by distance from the joint line.

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