Broach Extraction Forces in Total Hip Arthroplasty: Influence of Broach Handle Design on Mechanics and Loading Forces during Femoral Broach Extraction

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INTRODUCTION: Recent studies have shown that total hip arthroplasty (THA) broach handle designs, particularly those intended for limited exposure approaches, may cause intraoperative femoral fractures. However, these studies have focused on the biomechanical effects during impaction, without addressing the influence of broach extraction. While broach impaction is commonly regarded as the mechanism for increased periprosthetic fracture risk, extraction may not be recognized appropriately for its contribution to femoral loading and potential injury. This study examines the stress that occurs to the proximal femur when a broach is being removed from the femoral canal by manual extraction.

METHODS: Six different broach handle designs were simulated using a finite element model. Designs A, B, and C are commonly used straight broach handle designs. Designs D and E have large offsets created for limited exposure approaches. Design F is used for the same approach as Design E, but an alternate extraction location is used. Locations of the extraction force for each broach handle design are shown in Fig 1. Von Mises stress were calculated for the cortical wall for each of the extraction simulations. Stress contours are shown in Fig 2.

RESULTS: Fig. 2 shows maximum Von Mises stresses and resultant moments for each design as compared to Design A (straight broach handle). The largest increases in stresses and resultant moments, as compared to Design A, occurred in the large offset designs. Using an alternative extraction location, Design F showed similar stresses and moments as the straight broach handle designs. For all simulations, the areas of highest stress generally occurred in the posterior lateral neck and the medial calcar regions, two locations where intraoperative fractures commonly occur.

DISCUSSION AND CONCLUSION: Broach handle designs can influence increased loading of the proximal femur during broach extraction, possibly weakening or even fracturing the cortical wall. The location of peak forces during femoral broach extraction occur in the areas most commonly associated with periprosthetic fracture. It is important that surgeons are aware that broach extraction may play an important role in periprosthetic fracture risk. Although the etiology of intraoperative periprosthetic femur fracture is multifactorial, broach handle design and extraction technique should be an important consideration in the selection and use of instrumentation for total hip arthroplasty.

Design	X Offset (mm)	Y Offset (mm)	Z Offset (mm)
A	22	19	255
B	12	25	340
C	0	15	165
D	28	75	310
E	105	85	305
F	80	35	50