Computer Navigated Hip Resurfacing for Patients with Abnormal Femoral Anatomy

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Abstract

Hip resurfacing is a technically demanding alternative to total hip arthroplasty. The use of traditional jigs for placement of the femoral guidewire can lead to preparatory errors that may predispose the resurfacing construct to premature failure. Computer navigation is a tool that can be used to minimize the incidence of inadequate to detrimental preparation of the femoral head and improve the accuracy of component placement. Computer navigation not only shows promise in routine cases of hip resurfacing but also in those cases that are technically challenging. The current study demonstrated the utility of imageless computer navigation in placement of the femoral component for patients presenting with abnormal femoral anatomy.

Hip resurfacing arthroplasty continues to show promise as an alternative to total hip arthroplasty in the young, active adult. The aim of the procedure is to preserve femoral bone stock and recreate the native anatomy of the hip. Some of the challenges faced in previous generations of this type of arthroplasty remain, including femoral neck fracture and implant loosening.\(^1\) Optimal preparation of the femoral head is strongly encouraged as a means to minimize the occurrence of femoral implant failure by avoiding iatrogenic mechanical factors, such as femoral neck notching, varus implant alignment, and avoidance of exposed, reamed cancellous bone.\(^4\)\(^,\)\(^5\)

Hip resurfacing has been described as a technically demanding procedure and patient outcomes can suffer greatly from inaccurate and poorly prepared bone stock.\(^7\) The difficulty of the procedure increases greatly for patients who present with abnormal hip anatomy. Several investigators have shown relative success in hip resurfacing for patients exhibiting childhood disorders, including developmental dysplasia of the hip, slipped capital femoral epiphysis, and Legg-Calvé-Perthes disease,\(^8\)\(^,\)\(^9\) while others have shown disappointing results, specifically in the placement and longevity of the femoral component in such cases.\(^10\) Few have commented on resurfacing for the case in which abnormal proximal femoral geometry exists as the result of fracture or osteotomy repair, specifically with hardware remaining in situ.\(^11\)

Computer-assisted surgery is gaining popularity in hip resurfacing arthroplasty and shows potential as a means of increasing the accuracy of bone preparation and implant placement.\(^12\)\(^-\)\(^16\) Imageless computer navigation for hip resurfacing is not yet widely employed, but its advantages over traditional mechanical means have been described.\(^17\)\(^-\)\(^23\) Computer navigation not only shows promise in routine cases of hip resurfacing, but also in those cases that are technically demanding. The current study demonstrated the utility of imageless computer navigation in placing the femoral hip resurfacing component in patients exhibiting abnormal femoral anatomy.

Methods and Materials

Between October 2005 and September 2008, 165 consecutive navigated hip resurfacings were performed by the senior surgeon (EHS). Of this consecutive series, seven patients presented with extra-articular deformity or retained hardware that would make a total hip arthroplasty difficult.
study cohort consisted of six males and one female, who had a mean age of 51 years (range, 26 to 82 years). Their mean body mass index (BMI) was 34.7 kg/m² (range, 26.2 to 44.5 kg/m²). The primary diagnosis was osteoarthritis in five patients and osteonecrosis in two patients, with indications for hip resurfacing that included the following: 1. one patient had a severe varus deformity of the proximal femur (Fig. 1); 2. three patients presented with blade plates for proximal femoral osteotomy and fracture fixation (Fig. 2); 3. one patient had a tantalum osteonecrosis rod (Fig. 3); and 4. two patients had femoral necks that contained threaded pins from a previous neck fracture (Fig. 4). A standard postero-lateral approach was used in all cases, with implantation of a Birmingham Hip Resurfacing System (Smith & Nephew, Memphis, Tennessee), which is a hybrid resurfacing system employing a press-fit acetabular cup and a cemented femoral component. For statistical analysis, patients within the study cohort were matched to patients within the hip resurfacing series in a 2 to 1 ratio for primary diagnosis, gender, age, and BMI. The mean age of the matched cohort was 51 years (range, 26 to 73 years), and their mean BMI was 33.7 kg/m² (range, 21.3 to 45.9 kg/m²).

**Preoperative Planning**

Preoperative planning was performed using modified digital anteroposterior (AP) unilateral hip radiographs, displaying the lateral pelvis and the proximal two-thirds of the femur. The radiographs were scaled and templated for femoral and acetabular component sizes. The templated femoral component was positioned in a suitable valgus orientation and the angle the component made with the diaphyseal axis was the stem-shaft angle (SSA). The planned SSA was recorded for use in the navigation process. Valgus orientation of the femoral component is recommended in the literature and has been shown to mechanically strengthen the resurfacing construct. We routinely plan
approximately 5° to 10° of valgus alignment relative to the native neck-shaft angle or in the cases of retained hardware an acceptable alignment permitted by the hardware in situ. Lateral radiographs were used to help gauge the position of the prostheses in the neck and in the cases of retained hardware in the femoral head and neck, the relative position of the stem of the resurfacing component. Postoperatively, 3-month AP unilateral hip and lateral hip radiographs were used to assess component position.

Imageless Computer Navigation

The BrainLAB VectorVision SR 1.0 (BrainLAB, Heimstetten, Germany) imageless computer navigation unit was used in all cases for intraoperative planning and guidewire insertion. Patient anatomy was registered according to the requirements of the navigation system. Following registration, a patient-specific morphed model was generated and used to plan the implant position. A hand-held drill guide was applied to guide the drilling of the initial guidewire. Upon insertion, the guidewire position was verified by the navigation system. A stylus was inserted over the guidewire to check for notching and proper resection of the femoral head. The femoral head was subsequently prepared following the standard surgical protocol. The time for navigation was recorded for each case.

Results

There were no intra- or postoperative surgical complications to report. Upon examination of 3-month postoperative AP and lateral radiographs, femoral components appeared

Figure 3 Patient with Tantalum osteonecrosis rod in situ: (A) preoperative, (B) preoperative plan, and (C) postoperative AP radiograph with inset (arrow shows tip of osteonecrosis rod on chamfered edge of femoral head adjacent central canal).

Figure 4 Patient with retained threaded pins for previous femoral neck fracture: (A) preoperative, (B) preoperative plan, and (C) postoperative AP radiograph.
well-positioned in the coronal and sagittal planes, with no signs of femoral neck notching. The mean deviation of the postoperatively assessed SSA from the preoperative plan was 0.6° (SD 3.5, range, -5° to 6°). The mean navigation time was 18 minutes (SD 6; range, 11 to 27 minutes). The mean postoperative SSA error and navigation time for the matched patient cohort was 1.6° (SD 2.2, range 1 to 6) and 18.6 minutes (SD 9.9, range 10 to 50), respectively. There were no significant differences between patients in the study cohort and matched subjects with respect to SSA error (p = 0.464) and navigation time (p = 0.904).

Discussion

The use of computer-assisted surgical techniques is growing in popularity, specifically in hip resurfacing arthroplasty, providing the benefits of increased accuracy and a reduced learning curve. Computer navigation for placement of the femoral component reduces much of the inaccuracy introduced by the surgeon with the use of conventional mechanical alignment instruments by eliminating the error inherent in visual alignment and replacing it with absolute measures of implant position. In addition, imageless navigation does not require a lateral cortex pin, as is required with several mechanical alignment jigs. Insertion of a lateral pin may be difficult in cases in which hardware is fixed to the lateral cortex of the femur.

Hip resurfacing presents an attractive alternative to conventional total hip replacement for patients with proximal femoral deformity or retained hardware. Total hip arthroplasty in conjunction with corrective osteotomy has shown limited success. Papagelopoulos and colleagues reported on 20 primary conventional total hip arthroplasties, all requiring simultaneous corrective osteotomy for proximal femoral deformity. Half of the patients experienced complications, including intraoperative femoral fracture, dislocation, osteotomy nonunion, aseptic implant loosening and instability; a subsequent 30% reoperation rate was reported. Others have shown varying success with primary total hip replacement in conjunction with osteotomy or hardware removal; however, lengthy osteotomy union and healing times, as well as high rates of complications appear consistent with this form of complex primary total hip arthroplasty.

For appropriate patients, hip resurfacing may eliminate the need for corrective femoral osteotomy or the removal of proximal femoral hardware. Mont and coworkers performed primary metal-on-metal hip resurfacing in 15 patients (17 hips) presenting with proximal femoral deformity or retained hardware. At a mean follow-up time of 3 years, 14 patients (16 hips) were doing well both clinically and radiographically, with only one patient requiring revision for a femoral neck fracture and subsequent implant loosening. In a similar manner, the current study demonstrated the efficacy of hip resurfacing for patients with abnormal femoral anatomy, specifically with the use of imageless computer navigation for placement of the femoral component. Complex, primary hip resurfacing is a viable option for patients with abnormal femoral anatomy or retained proximal femoral hardware, and the accuracy of placement of the femoral component is enhanced with computer navigation. The limitation of hip resurfacing in these complex cases, however, is the requirement for appropriate femoral head and neck geometry on which to seat the femoral component.

Imageless computer navigation for hip resurfacing can be an effective tool to aid the surgeon in femoral head preparation. However, it is imperative that a prudent preoperative plan be carried out prior to intraoperative use of navigation to ensure accurate and well-positioned implants. Patient selection in hip resurfacing is critical and the use of computer navigation cannot correct for poor patient selection. In addition, poorly selected landmarks and careless registration can remove much of the benefit of navigation. Navigation can increase, however, the accuracy of implant placement and reduce the incidence of mechanical preparatory error if utilized properly. The current study demonstrated the merit of imageless computer navigation for placement of the femoral component in difficult cases of hip resurfacing arthroplasty. Additional follow-up of patients receiving peri-prosthetic hip resurfacing and hip resurfacing for malformed proximal femoral anatomy is warranted to determine the efficacy of hip resurfacing arthroplasty as an intervention in this patient population.

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Disclosure Statement

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References


