Computer-assisted navigation as a diagnostic tool in revision total hip arthroplasty: A case report

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Abstract
Revision total hip arthroplasty is a costly procedure accounting for approximately 14% of all hip arthroplasties. Compounding the cost considerations is the potential for serious injury to the patient when removing existing components. Such injury can result in not only increased morbidity but also dramatically increased costs. The use of computer-assisted navigation in revision total hip arthroplasty, while relatively uncommon, offers surgeons the ability to measure component position and orientation intraoperatively, thus allowing them the opportunity to modify their surgical plan, with the potential for decreasing both costs and iatrogenic injury. Here, we report a case of revision total hip arthroplasty where the use of computer-assisted navigation as a diagnostic tool allowed for intraoperative alterations in surgical plan and resulted in improved post-operative outcomes.

Keywords
Total hip arthroplasty, computer-assisted navigation, revision total hip arthroplasty

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Introduction
Despite its overall high success rate, total hip arthroplasty (THA) is nevertheless associated with gradual wearing of components and subsequent revision surgery in up to 13.9% of cases.¹ Given the expected two-fold increase in the demands for revision THA (rTHA) in the coming decade¹ and the high costs of revision procedures, which can reach $54,000 per case in the United States,² the importance of methods that help maximize component longevity, especially in revision procedures, is obvious.

Key in maximizing component longevity is the accurate placement of components during THA.³ Computer-assisted navigation, an increasingly common adjunct to primary THA, has demonstrated an excellent ability to improve component accuracy, although there are few studies reporting the use of this technology in rTHA.⁴ Here, we report a case of rTHA performed with the assistance of an imageless computer navigation system, the use of which resulted in intraoperative alterations in the surgical plan that would not have otherwise been possible.

Case presentation
A 58-year-old female presented with a chief complaint of left hip pain of 5 months’ duration. The patient had been seen approximately 10 months prior to presentation, shortly after experiencing a “clunk” in her right hip. She reported that her pain was stable and had not increased since that episode. Relevant history included a left primary THA approximately 25 years ago. The patient also reported a right primary THA at the age of 33 years, followed by a head and liner exchange 10 years later due to poly wear and broken tine. A right total knee arthroplasty procedure was performed approximately 1 year ago. Comorbid conditions reported included degenerative joint disease, thrombocytopenia, cirrhosis of the liver, lumbar spondylosis and anemia. The patient had been managing any ongoing hip pain with anti-inflammatories and routine monitoring of poly wear with annual radiographs.

On physical examination, a pain-free range of motion (ROM) of the affected hip was noted, although the patient demonstrated hesitation at the extremes of motion. Slightly reduced ROM was noted with internal and external rotation.
when compared with the right hip. Erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) were normal. Radiographs were obtained and revealed severe polyethylene wear and asymmetry in the left hip (Figure 1). Some acetabular and proximal femoral lysis was noted, although there was no change in the acetabulofemoral component interface.

The pre-operative plan for this patient was to exchange the polyethylene liner only; however, during surgery, it was observed that the locking mechanism on the poly component was incompetent. Furthermore, intraoperative measurement with the navigation system indicated anteversion of 5° (radiographic definition), revealing a cup component significantly more retroverted than the 18° indicated by the pre-operative radiograph (Figure 2). A decision was made to exchange both the liner and the cup component (Figure 3).

Surgery was successful, and post-operatively, the patient was prescribed standard posterior hip precautions with toe-touch weight-bearing for 6 weeks. At 2 weeks post-op, the patient was progressing well.

Discussion

Revision THA is a costly procedure that places a substantial financial burden on the healthcare system. With costs reaching US$50,000 per procedure, revision THA alone is responsible for potential annual expenditures of over US$2 billion per year.2,5 With cost-containment an ongoing consideration in today’s healthcare climate, especially given the proposed bundled payment system for procedures such as THA,6,7 there is an enhanced need for cost-saving solutions in THA.

The case summarized in this report utilized an imageless, computer-assisted navigation system (Intellijoint HIP®; Intellijoint Surgical, Inc., Waterloo, ON) to provide intraoperative cup position data.8–10 Acetabular orientation is measured by the device using the radiographic definition of cup position, to provide measurements that align closely with those provided by pre- and post-operative radiographs, thus minimizing the likelihood of error associated with the use of differing frames of reference.11,12 In the presented case, the data provided by the navigation device were integral in intraoperative decision making. The case demonstrates the value of accurate measurement of the position of the acetabular cup component during revision THA,
measurements that provide the opportunity for alterations in the surgical plan. In cases where the acetabular component is fixed and stable and in an appropriate orientation, preservation of the cup becomes a viable option, one that can help limit both the potential injury associated with the removal of components that may be firmly held in place by years of bony ingrowth and the costs associated with that removal. For the device used in this case, the potential savings in preserving components greatly offset any costs associated with the device (no capital costs, $1200–$1400 per use). Indeed, this has been illustrated in a previous report of rTHA using this device, where intraoperative measurements allowed for preservation of the cup component, thus saving the far greater costs associated with both the new implant and the additional operating room (OR) time. In the current case, the revision of the cup component as well as the femoral components, based on intraoperative data provided by the navigation device, should contribute to improved long-term stability, as the initial cup was found to be in a sub-optimal orientation.

Previous studies have documented significant acetabular and pelvic injuries and loss of native bone stock associated with the removal of an inserted cup. Furthermore, as acetabular component malposition is known to contribute substantially to instability and dislocation, and the risk of dislocation increases as the cup becomes more retroverted, the ability to not only identify a malpositioned cup but also to optimize the orientation of the new cup contributes to the long-term stability of the new joint and helps to minimize the potential for post-revision dislocations and re-revision surgery. Finally, the increased costs associated with bone grafts or specialized cup components when inserting a new implant can be significant. The ability to measure the orientation of the cup intraoperatively and make alterations to the surgical plan thus represents an important adjunct to rTHA, one that has the potential to decrease both costs and the potential for injury.

Conclusion

Given the increased costs and potential for injury in revision THA, the ability to intraoperatively measure cup position and inform intraoperative decision-making is an important addition to rTHA. While there is currently little evidence available in the literature on the specific use of computer-assisted navigation in rTHA, the case discussed here suggests a potential role for navigation during this common procedure. While this role requires further research to fully characterize, surgeons performing revision THA may wish to consider the addition of navigation to their procedural toolbox.

Declaration of conflicting interests

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Ethics approval

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Informed consent

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