Outcomes of an imageless, computer-assisted revision total hip arthroplasty using a constrained cemented liner: A case report

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Abstract

Dislocation due to unstable components following total hip arthroplasty (THA) is one of the most common reasons for revision surgery. Computer-assisted navigation has proven the ability to increase the accuracy with which components are placed. The present case summarizes a case of revision total hip arthroplasty utilizing a constrained, cemented liner and an imageless computer-assisted navigation system. Intraoperative use of the navigation tool facilitated the placement of the new constrained liner and post-operative radiographs confirmed the exact positioning. Computer-assisted navigation may therefore be an effective tool to improve the accuracy of component positioning during revision surgery with a constrained, cemented liner.

Keywords
Orthopaedics, rehabilitation, surgery, computer-assisted navigation, revision, total hip arthroplasty

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Introduction

The rate of dislocation following primary total hip arthroplasty (THA) ranges from 0.3% to 10% \cite{1-4} and increases to 10% to 28% after revision THA \cite{1, 3-6}. Of those revision patients, 6% to 28% experience continuing dislocation \cite{7-12}. A suitable treatment option for individuals with recurrent dislocations is the use of a constrained liner, where the femoral head is mechanically constrained within the polymeric liner. Constrained acetabular liners have the advantage of a capture mechanism which physically prevents dislocation from occurring. The constrained cup liner extends beyond the hemisphere of the cup component and has a mouth that is smaller than the mating head. The head is thus securely contained within the liner through mechanical expansion of the inner diameter of the rim. Once the head is in place, an external metal ring is attached to the liner to prevent it from shifting, thereby maintaining the head within the articulation. Recurrent instability following revision surgery has been successfully addressed by constrained liners previously (2-7% rate of dislocation) \cite{2, 13}.

Recently, evidentiary material has noted the benefit of computer-assisted navigation in optimizing the accuracy with which acetabular components are positioned in revision THA \cite{14-17}. The present report summarizes the use of an imageless navigation tool in a difficult case of revision THA in which a constrained liner was used.

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Case report

Patient presentation

A 46-year old male presented with a chief complaint of recurrent left-sided hip dislocation. The patient had undergone his first revision procedure approximately nine months previously, following a dislocation. Following that revision, he continued to experience dislocations, now numbering four. On physical examination, leg lengths were revealed to be equal. Hip range of motion was functional. Neurological testing was unremarkable. Plain film radiographs (AP pelvis) revealed all structures surrounding the hip were structurally sound. On pre-operative imaging, the acetabular component was oriented with suspected mild retroversion and inclination of 44° (Fig. 2A,B). Following consultation with the patient, a decision was made to proceed with a revision THA with a constrained, cemented liner. The goal was to preserve the existing acetabular component in its same orientation but to modify the position of the liner.

Treatment

Surgery was performed with the assistance of the Intellijoint HIP® mini-navigation tool (Intellijoint Surgical Inc., Waterloo, Ontario, Canada), currently FDA-cleared for use in primary and revision THA using the posterior, lateral and direct anterior surgical approaches. The indications and instructions for use of the device have been described in detail elsewhere [18, 19]. Briefly, the device consists of a camera, mounted to a platform fixed to the iliac crest via two surgical pins, and an optical tracker, which can be mounted to the greater trochanter via a femoral platform or to other surgical tools (e.g. probe, impactor). The camera transmits positional data to a laptop workstation outside of the sterile field but within view of, and controlled by, the surgeon (Figure 1).

Figure 1. The Intellijoint HIP® Navigation System
The camera (A) is enclosed in a sterile drape and magnetically attaches to the pelvic platform (B). The pelvic platform is installed on the ipsilateral iliac crest using two pelvic screws (C). The tracker (D) is magnetically attached to the femoral platform (E). The camera captures movements of the tracker and relays the information to a workstation for review by the surgeon.

The navigation device was installed, and the patient registered per the standard device use [18]. Prior to removal of the existing cemented liner, the navigation device was used to measure the orientation of the acetabular components. By attaching the device’s tracker to a surgical probe, the device can determine the real-time orientation of the cup and/or liner components by marking three points on the face of the component. Using this method, the existing acetabular shell was confirmed to be retroverted at -10° and the cemented liner was measured at 53° of inclination and 6° of anteversion (Figure 2). Based on these measurements, it was felt that the existing liner was too inclined and not anteverted sufficiently to prevent dislocation. A new liner was cemented into the existing acetabular shell in an orientation of 47° inclination and 13° anteversion, confirmed by the navigation device and consistent with the pre-operative plan. The hip was reduced, and the device hardware was removed prior to closure. Post-operative imaging confirmed satisfactory placement of new components (Figure 3).

Surgical procedure

The patient was placed in the lateral decubitus position. The left hip and lower extremity were prepped and draped in the usual sterile fashion.
Figure 2. Pre-operative imaging demonstrated a displaced femoral head due to liner failure (A). Acetabular cup component orientation (B) was confirmed by the navigation device prior to hardware removal.

Follow-up

Post-operatively, the patient was doing well with no pain and full return of mobility. At his 12-week follow-up visit, the patient stated he was back to most of his physical activities and was happy with his progress. The patient experienced no further dislocations following revision surgery.

Figure 3. Post-operative images revealed the new femoral head seated within the constrained liner.

Discussion

Dislocation following THA is one of the foremost adverse events responsible for reoperation, second only to aseptic loosening [20, 21]. The risk of dislocation following revision surgery is considerably higher than the risk following primary THA (9% versus 21%) [21-23]. One of the ways to mitigate consistent dislocation following revision THA is the use of a constrained, cemented liner which physically averts dislocation. Components that are
Constrained offer immediate stability as impingement forces are diffused through the component locking mechanism. This report summarizes a case were a constrained, cemented liner was used in tandem with an imageless navigation system. The imageless system provided a versatile solution to a difficult case of revision THA.

Constrained acetabular inserts are generally used as a salvage procedure for treating elderly patients with instability of uncertain aetiology, neurological impairment, deficient hip abductors. They have demonstrated 70-95% success in addressing instability in short-term follow-up studies [24], and have shown a significant reduction in recurrent dislocations following revision THA [25]. Additional studies have looked at the outcomes of constrained liners and found positive outcomes. Goetz et al., [2] reported no additional dislocations in 54 of 56 hips (96.4%) treated for recurrent instability and Shapiro et al., [13] reported no dislocations in 83 of 85 hips (97.6%).

The patient discussed in this report had suffered frequent dislocations following their initial revision procedure. The acetabular cup had been placed in a retroverted position purposefully to help address this issue. Consequently, the aim of the current procedure was to maintain the current corrective orientation of the cup but to modify the liner positioning to provide improved stability. Image-guided computer navigation systems would be of no aid in this situation, as image-guided devices do not have the capability to measure the position of the cup in real-time, i.e. before the cement is fully dried. An imageless navigation system was therefore used to provide a fast and accurate trial of the positioning needed to prevent dislocations. Imageless navigation has shown merit in other challenging conditions such as revision THA [26], Birmingham hip resurfacing [27] and Legg-Calve-Perthes Disease [28]. In this case, the capability of the imageless navigation device to measure the orientation of the liner intraoperatively and make adjustments to the surgical plan represents a significant adjunct to the use of cemented liner. By ensuring a more accurate and efficient surgery, potential cost to the patient and post-surgical adverse events are could be lessened.

Preventing adverse incidents with technologies that enable more accurate component placement can provide patients with improved post-procedure outcomes [29]. The ability to confirm data intraoperatively was imperative, specifically for this case, as that information was able to help to improve component placement. Increased accuracy of component positioning is likely to decrease the chance of recurrent dislocation revision surgery [30, 31]. In this case, the placement of the component was even more imperative, as the constrained design of the femur head represents a long-term solution to recurrent dislocation. The permanence of this approach requires careful execution. The device provided real-time intraoperative data that helped to ensure that components were implanted in an orientation that would allow for long-term stability. The patient is not yet 50 years old, and therefore the liner and acetabular component must remain durable for an extended period of time.

Conclusion

This report summarizes a case of revision total hip arthroplasty performed with the assistance of an imageless, computer-assisted navigation device. The device provided intraoperative measurements that confirmed the pre-operative plan which allowed for improved accuracy with component placement and improved outcomes following surgery. Life expectancy of the general population is rising, meaning the indications for total hip arthroplasty are expected to expand. Consequently, the number and complexity of acetabular revisions are probable to increase. The unique ability of this device to provide intra-operative information could be imperative for future endeavours.

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Case Report

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