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Original Research

Dual-Mobility Constructs in Primary Total Hip Arthroplasty in High-Risk Patients With Spinal Fusions: Our Institutional Experience

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ABSTRACT

Background: Prior spinal fusion significantly increases the risk of dislocation in patients after total hip arthroplasty (THA). Owing to these high risks, surgeons may use dual-mobility (DM) constructs in these patients to optimize hip stability. However, there is a paucity of data on the outcomes of DM constructs in patients who underwent prior spinal fusions.

Methods: We retrospectively identified 80 patients (86 THAs) who underwent a spinal arthrodesis and a subsequent posterior approach THA with a DM construct. The median number of levels fused was 4, with 59 (74%) patients having 2 or more levels fused; in addition, 50 (63%) patients were fused to the sacrum. Ninety percent and 55% of THAs were within the Lewinnek safe zone for inclination and anteversion, respectively. Patients were evaluated for any episode of hip instability, complications, and patient reported outcome measures.

Results: At 3-year mean follow-up, no patients sustained a postoperative dislocation or intraprosthetic dislocation (0%). Overall, there were 6 (7.5%) complications during the study period leading to reoperation in 3 (4%) patients, none related to the acetabular component or instability. Hip Injury and Osteoarthritis Outcome Score, Joint Replacement scores significantly improved from a mean of 50 preoperatively to 87 postoperatively ($P < .001$), and the Veterans Rand 12 Item Health Survey physical score improved from a mean of 31 preoperatively to 44 postoperatively ($P < .001$).

Conclusion: In a high-risk series of patients who underwent prior spinal fusion, posterolateral primary THA with a DM construct demonstrated no dislocations at mean 3-year follow-up. Although these early data are clearly encouraging, more patients with longer term follow-up are needed.

Introduction

Dislocation remains one of the most common complications after primary total hip arthroplasty (THA) and a leading cause of revision THA [1-3]. Patients who underwent prior spinal fusions, especially multilevel and to the sacrum, are at particularly high risk of dislocation, with reports of up to 10% [4-14]. Owing to their altered spinopelvic immobility, these patients are at high risk for impingement and, therefore, dislocation [8,10]. Although efforts continue to define overall and patient-specific safe zones for acetabular component positioning in relation to spinopelvic immobility, exact acetabular component position that is ideally suited for each patient is unknown [15-17] and can change with additional acquired stiffness or spinal fusions [9,13,18]. Therefore, dual-mobility (DM) constructs have become an attractive option to surgeons for these patients [17].

Multiple systematic reviews and case series report reduced dislocation rates of DM constructs in high-risk patients undergoing primary and revision THAs [19-22]. DM constructs increase the effective impingement-free range of motion, which is the etiology of dislocation in patients who underwent spinal fusions, by adding a second articulation and increasing the effective femoral head size and jump distance [19-22]. However, there is a paucity of data on the outcomes of DM constructs in patients who underwent a prior spinal fusion.

As such, the goal of the present study was to analyze the outcomes of patients undergoing primary posterolateral THA with DM constructs who had undergone a prior lumbar spinal fusion at a single institution. Specifically, we sought to analyze (1) dislocations, (2) other complications, and (3) patient-reported outcome measures (PROMs).

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Patients and methods

We retrospectively identified through an institutional electronic medical record all patients who underwent a spinal fusion surgery and subsequent posterolateral THA with DM components from 2012 to 2018 at a single tertiary care academic center. To minimize bias and obtain the most complete records, we did not include patients who underwent a spinal fusion at an outside facility that subsequently had a THA performed at our institution. We performed a thorough radiographic and chart review to assess operative details, specifics of their prior spinal fusion, complications, and PROMs. Patients were followed up until revision, reoperation, or latest clinical follow-up. Because 75% of dislocations occur within 1 year of THA, minimum clinical follow-up was 1 year [23]. Thirty patients (30 THAs, 38%) who had not had 1 year of clinical follow-up were contacted via telephone to assure that they had not sustained a dislocation or additional complications and to update their PROMs. Patients were excluded if they underwent an anterior or lateral surgical approach, if they had incomplete records, or if they did not have at least 1 year of clinical follow-up or could not be reached via telephone. Preoperative and postoperative radiographs were analyzed for the number of spinal levels fused, fusion to the sacrum, and acetabular component positioning measured by a previously described method [16,24,25]. Institutional review board approval was obtained before study initiation.

Patients

Eighty-seven patients (94 THAs) who underwent a THA after spinal fusion were identified (Fig. 1). No patients died before 1-year minimum follow-up, but 7 patients (8 THAs) were lost to follow-up and could not be reached when contacted for follow-up. Therefore, the study consisted of 80 patients (86 THAs). Fifty-seven (71%) patients were female. The mean age was 69 years (range, 53 to 87 years). The mean BMI was 28 kg/m^2 (range, 18-42 kg/m^2). The mean follow-up was 3 years (range, 1-7 years) after primary THA (Table 1).

Table 1
Patient demographics.

Patient demographics	
Patients, No.	80
THAs, No.	86
Females, No. (%)	57 (71%)
Mean age, y (range)	69 (53-87)
Mean body mass index (BMI), kg/m^2 (range)	28 (18-42)
Median number of levels fused, No. (range)	4 (1-14)
Fusion levels	
Single level, No. (%)	21 (26%)
2-4 levels, No. (%)	37 (46%)
5 or more levels, No. (%)	22 (28%)
Fused to the sacrum, No. (%)	50 (63%)
Mean acetabular component size, mm (range)	52 (44-62)
Mean effective femoral head size, mm (range)	42 (36-52)

Prior spinal fusion

All spinal fusion surgeries were performed at the same institution as the THA by surgeons with expertise in spine surgery. The mean time between spinal fusion surgery and THA was 3.4 years (range, 6 months-13 years). The mean number of fusion surgeries

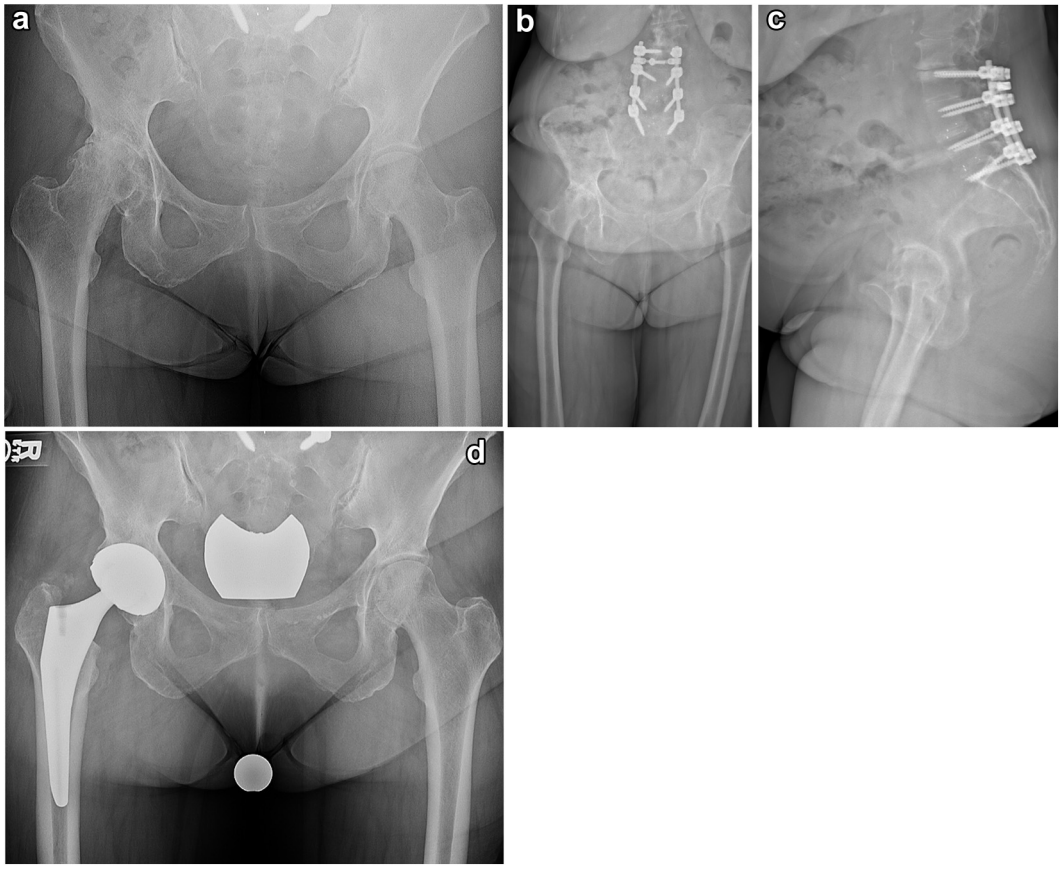

Figure 1. Preoperative anteroposterior (AP) pelvis radiograph (a) of a patient with end-stage right hip osteoarthritis that also has a 3-level spine fusion from L3 to the sacrum (b and c). She underwent a right THA with a dual-mobility articulation (d) and did well at 2-y postoperative follow-up without dislocation.

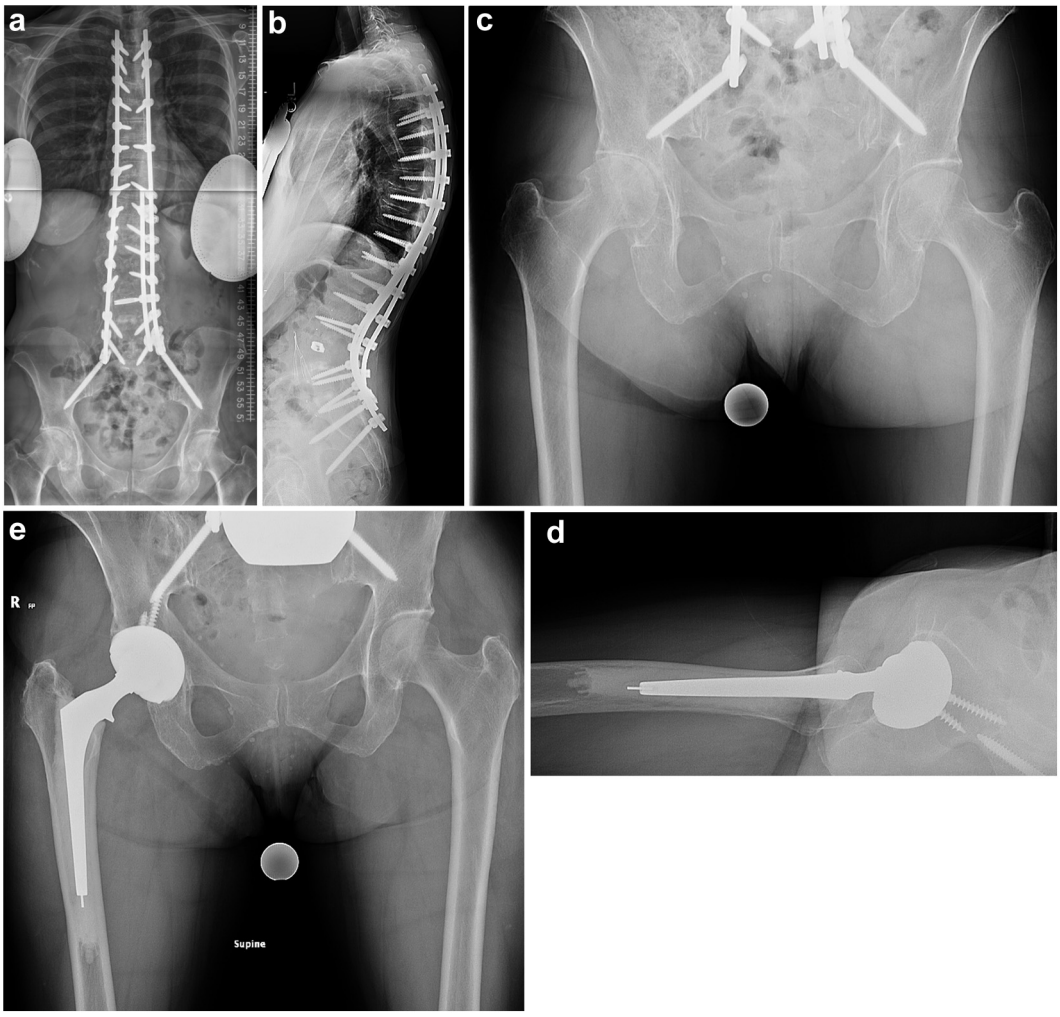

Figure 2. Preoperative AP (a) and lateral (b) scoliosis radiographs of a 67-y-old female after a 14-level fusion from T4 to the sacrum with end-stage right hip osteoarthritis evident on the AP pelvis radiograph (c). She underwent hybrid THA (d and e) with a DM construct and did well at 3 y of clinical follow-up without dislocation.

was 1.3 (range, 1-3 fusions). The median number of levels fused was 4 levels (range, 1-14 levels). Twenty-one (26%) patients underwent a single-level fusion, 37 (46%) patients underwent 2 to 4 level fusions (Fig. 1), and 22 (28%) patients had 5 or more levels fused (Fig. 2). The sacrum was fused in 50 (63%) patients.

Primary THA

All patients underwent a primary posterolateral THA performed by multiple surgeons (n = 19) experienced in primary and complex revision THA at a single academic institution. The decision to use a DM construct was surgeon dependent but secondary to increasing concern for dislocation in high-risk patients who underwent spinal fusion. While utilization of DM constructs varies from surgeon to surgeon, all surgeons used them selectively for patients deemed higher risk for dislocation throughout this study's timeframe. There was a growing trend to use DM constructs in these patients over time with increasing recognition of this high-risk group and increasing utilization of DM constructs; 72 (83%) THAs in this study were performed in 2015 or later.

Acetabular components implanted in these patients were as follows: 31 (36%) Trident hemispherical cups (Stryker, Mahwah, NJ), 30 (35%) anatomic dual-mobility cups (Stryker), 16 (19%) Trident II 3D additively manufactured cups (Stryker), 8 (9%) G7 (Zimmer Biomet, Warsaw, IN), and 1 Tritanium revision cup (Stryker). Fifty-six (65%) DM constructs were modular, consisting of a cobalt-chrome metal liner, a large polyethylene bearing, and an inner femoral head. The remaining 30 (35%) THAs were monoblock DM constructs. The median overall acetabular cup size was 52 mm (range, 44-62 mm). The median effective femoral head size of the polyethylene bearing size was 42 mm (range, 36-52 mm). The femoral head size is dictated by the specific implant system based on the size of the acetabular component and whether the acetabular shell is monolithic (ie, anatomic dual-mobility) or modular dual mobility. Twenty-eight–millimeter femoral heads are manufactured in several different material options (cobalt-chrome, ceramic, and Oxinium) depending on the femoral stem manufacturer, while 22-mm femoral heads are only manufactured in cobalt-chrome. Seventy-two (84%) femoral heads were 28 mm; of those, 37 (43%) were ceramic (CeramTec, Germany), 15 (17%) were Oxinium (Smith and Nephew, United Kingdom), and 20 (23%) were cobalt-chrome. Fourteen (16%) femoral heads were 22 mm, all of which were cobalt-chrome.

The mean acetabular cup inclination was 44° (range, 30° to 57°). Seventy-eight (90%) of the THAs were within the Lewinnek safe zone for inclination. The mean acetabular component anteversion was 24° (range, 12° to 40°). Forty-eight (55%) THAs were within the Lewinnek safe zone for anteversion; however, all THAs that were

outside the safe zone had increased anteversion (none had less than 5° of anteversion), with only 7 of those THAs being anteverted more than 30°. Twenty-eight (33%) THAs were robotic or computer navigated with the following: a haptic robotic arm (Mako, Stryker) in 14 (16%) THAs, HipAlign (OrthAlign, Aliso Viejo, CA) in 8 (9%) THAs, and Intellijoint (Intellijoint, Kitchener, ON) in 6 (7%) THAs. The remaining 58 (67%) THAs were performed without navigation assistance.

Statistical analysis

All data are presented as mean values with ranges. The Kaplan-Meier method was used to analyze survivorship free from dislocation. Unpaired student *t*-tests were used to analyze all continuous variables [Hip Injury and Osteoarthritis Outcome Score, Joint Replacement (HOOS Jr.) and Veterans Rand 12 Item Health Survey (VR-12) preoperatively to postoperatively]. Statistical significance was set at alpha <0.05.

Results

Dislocations

No patients in this study sustained a postoperative dislocation at a mean follow-up of 3 years. Furthermore, no patients sustained modular liner dissociation or an intraprosthetic dislocation. As such, survivorship free from dislocation was 100% at both 2 and 5 years.

Complications

Overall, 6 (7.5%) patients experienced a complication. Of these, 3 (4%) patients underwent reoperation. One patient underwent an isolated femoral revision 2 months postoperatively after sustaining a Vancouver B2 periprosthetic fracture from a fall. One patient underwent a superficial irrigation and debridement for a superficial wound infection without deep penetration at 1 month postoperatively. The final patient underwent a 2-stage revision arthroplasty for a chronic prosthetic joint infection at 6 months postoperatively. Two (2.5%) patients developed a lower extremity deep venous thrombosis and underwent 3 months of anticoagulation without further negative sequelae. Finally, one (1.3%) patient sustained a minimally displaced greater trochanteric fracture 1 month postoperatively that was successfully treated nonoperatively.

Clinical outcomes

HOOS Jr. scores significantly improved from a mean of 50 (range, 21-76) preoperatively to 87 (range, 33-100) postoperatively ($P < .001$). The VR-12 physical score improved from a mean of 31 (range, 17-51) preoperatively to 44 (range, 21-61) postoperatively ($P < .001$). The VR-12 mental score improved from a mean of 42 (range, 19-69) preoperatively to 53 (range, 29-72) postoperatively ($P < .001$).

Discussion

Dislocation remains one of the most common early complications after posterolateral primary THA [1-3,16]. There is growing evidence that patients who underwent spinal fusion are at the highest risk for postoperative dislocation, with some reports of up to a 10% dislocation rate [4-14]. The spinopelvic immobility in these patients can lead to bony impingement, causing postoperative instability [8,10]. As DM constructs provide a greater range of motion to impingement and a larger jump distance, they have become attractive options in patients at high risk of impingement and dislocation [19-22]. In the present study, a series of high-risk patients who underwent spinal fusion and posterolateral primary THA with a DM construct did not experience any postoperative dislocations at a mean follow-up of 3 years (range, 1-7 years), even with a range of acetabular component positioning.

Historically, we have studied hip instability at our institution and have more recently recognized that high-risk groups do indeed exist. As a point of reference, in 2011, Schroder et al. [26] evaluated 436 alumina-on-alumina cementless primary THAs and found that 1.1% of this cohort had recurrent dislocation that required revision surgery with an average 3-year follow-up. Clearly, the overall rate of dislocation that required closed reduction (but not revision surgery) would have been considerably higher, but this was not reported. In 2012, Robinson et al. [27] studied the effect of restoration of combined offset on the stability of large-head (32 mm and 36 mm) THA in a series of 668 patients. The authors noted an overall dislocation rate of 1.3% and that the majority of hips that dislocated had a negative combined offset. In a comparative study from the authors' institution in which a high-risk group of patients younger than 55 years was evaluated, Rowan et al. [28] performed a matched cohort study of DM vs fixed-bearing THA. In this series with 3-year mean follow-up, the cohort of patients with DM did not experience any dislocation (0%), whereas the matched group of patients with fixed-bearing younger than 55 years had a dislocation rate of 5.1%. Finally, Esposito et al. [12] studied patients with fixed spinopelvic alignment who underwent THA and noted a higher risk of dislocation. In that series, the authors evaluated lateral sitting and standing radiographs postoperatively and concluded that 11 of the 12 dislocators had multilevel lumbar arthritis, with 4 of these patients having undergone surgical spine fusion before THA and only one patient who experienced dislocation had a "normal spine." This was the first study from our institution to highlight the fact that patients with pre-existing lumbar pathology, either arthritis or lumbar fusion, are considered a high-risk group for hip instability after THA.

In the present study, high-risk patients with prior spinal fusions undergoing primary posterolateral THA with a DM construct did not experience any dislocations at a mean of 3 years of follow-up (range, 1-7 years). There is growing evidence that this patient population is at significant risk of postoperative dislocation [4-14]. In a matched propensity study, Perfetti et al. [6] reported a sevenfold increased rate of postoperative dislocation in patients who underwent prior spinal fusion compared with controls. Moreover, in a Medicare database analysis, Malkani et al. [7] reported a 293% increase in the number of THAs performed on patients who underwent prior lumbar fusions from 2002 to 2014. Furthermore, patients who underwent fusions of 3 to 7 levels had a 3-fold increased rate of dislocation [5]. In a matched control analysis, Salib et al. [11] found that fusion to the sacrum with multiple lumbar level involvement was nearly a 5-fold risk of dislocation compared with controls without a spinal fusion. Therefore, the importance of determining the optimal construct to maximize hip stability and minimize complications in high-risk patients who underwent spinal fusion is of significant importance. In light of the aforementioned findings, the absence of dislocation in our study is quite promising.

Furthermore, there were no dislocations despite the variability in the acetabular component position, with 90% and 55% of cups being within the Lewinnek safe zone for inclination and anteversion, respectively. Traditionally, acetabular component malposition was considered the most important factor for dislocation; however, there is growing evidence that a majority of patients who experience dislocation have an acetabular component position within the Lewinnek safe zone [16] and that ideal acetabular component positioning may be patient specific [15]. While

adjustments to the component position based on spinal deformity and stiffness can be made, surgeons still do not know the exact ideal acetabular component position for each patient [15]. Even with computer-assisted navigation, execution of a planned component position is not always reliable secondary because of surgeon error, patient-specific factors, and patient positioning factors [25]. Furthermore, in patients with spinopelvic immobility, the pelvis does not accomodate the position of the femurs, leading to bony impingement independent of prosthetic impingement in many cases. Therefore, DM constructs have become attractive options for these patients to increase impingement-free stability and to attempt to mitigate these uncertainties [17]. However, there are little data in the literature regarding these assumptions, and the present study, to the authors' knowledge, is the largest in the literature analyzing outcomes of DM constructs for high-risk patients who underwent spinal fusion.

At short-term follow-up, there was an overall low complication rate, with no unique complications related to DM constructs and a reliable improvement in clinical outcome measures. In the present study, both hip-specific (HOOS, Jr.) and general health (VR-12) outcome measures significantly improved in patients who underwent a prior spinal fusion and undergoing a primary THA. However, in a recent systematic review [4], patients undergoing primary THA with prior lumbar fusions had poorer PROMs than patients who did not have a prior lumbar spine fusion. It is important for surgeons to recognize the impact of a prior spinal fusion on hip-specific function and complications (ie, dislocation) and overall health and quality of life to counsel this patient population appropriately.

We acknowledge several limitations of the present study. First, series at a single institution without a direct comparator group as the increasing awareness of this high-risk group induced an institutional trend to DM constructs a retrospective case for these patients. For clarity and transparency for any potential systematic review, 23 patients in this study were also included in a multi-institutional study that is yet unpublished; however, we thought it would be best to also include them in this study, given the different methodology used in this study and the completeness of the spinal fusion surgical history of patients in this present study. In addition, we did not want to eliminate any patients or surgeons ($n = 19$) from our "institutional experience" with DM constructs in patients who underwent spinal fusion to be as thorough as possible. Although this is the largest study of this high-risk patient population to the authors' knowledge, it is still relatively small; however, we selected patients who underwent prior spinal fusions and their THAs performed at the same institution to obtain the purest case series with the most information possible. Although DM THAs may mitigate the risk of postoperative instability regardless of the surgical approach, in our study, all the THRs were performed via a posterolateral approach, so we are unable to comment on other surgical approaches in this high-risk patient population; furthermore, there are no data in the literature to guide surgeons on the approach in patients who underwent spinal fusion. Finally, the average 3-year follow-up is considered short term. Although the vast majority of dislocations (up to 70%) occur within 1 year [16,23] after THA and the increase in the utilization of DM constructs has been in the short term, extended follow-up is clearly needed for this series of patients.

In conclusion, high-risk patients with prior spinal fusions undergoing primary posterolateral THA with a DM construct did not experience any dislocations at a mean follow-up of 3 years (range, 1-7 years) in this study. The patients in this series had multiple levels fused, a high number of fusions to the sacrum, and a range of acetabular component positions. As such, based on growing literature, these patients are particularly at high risk for postoperative instability, with rates reported up to 10% [4-14]. Although more patients and extended follow-up are required, the increased utilization of DM constructs may reduce the dislocation rate of high-risk patients who underwent spinal fusion patients and undergoing primary THA.

Conflict of interests

S.A. Jerabek receives royalties from Stryker, is a paid consultant for Stryker, and receives research support from Stryker; D. Mayman is a paid consultant for Smith and Nephew, holds stock ownership in OrthAlign, and receives research support from Smith and Nephew; G.H. Westrich receives royalties from Stryker Orthopaedics and Exactech, is a paid consultant for Stryker Orthopaedics and Exactech, is a member of the speakers' bureau/part of paid presentations for Stryker Orthopaedics, Exactech, and Mallinckrodt Pharmaceuticals, receives research support from Stryker Orthopaedics and Exactech, and is a board member for the Eastern Orthopaedic Association; and T.P. Sculco receives royalties from Exactech, is an unpaid consultant for Lima, and is member of the editorial/governing board of the *HSS Journal* and the *American Journal of Orthopaedics*; all other authors declare no potential conflicts of interest.

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