New Approach and Stem Increased Femoral Revision Rate in Total Hip Arthroplasty

Phonthakorn Panichkul, MD; Nancy L. Parks, MS; Henry Ho, MS; Robert H. Hopper Jr, PhD; William G. Hamilton, MD

Abstract

This study compared the femoral stem revision and loosening rates in primary total hip arthroplasty between 2 different approaches and stem designs. Recent reports comparing the direct anterior approach with either the posterior or lateral approach showed that patients undergoing the direct anterior approach have less pain and an accelerated functional recovery in the early postoperative period. After converting to an anterior approach, the authors observed an increased rate of femoral stem revision. From 2003 to 2009, a posterior or lateral approach was used to insert 514 stems of 2 designs. These cases included the use of an extensively coated cobalt-chrome stem (n=232) or a straight, dual-tapered, proximally porous-coated titanium stem (n=282). In the following years, from 2009 to 2012, 594 short, proximally coated, titanium tapered-wedge stems were inserted through a direct anterior approach. The revision rates of femoral stems inserted through a posterior approach or a lateral approach were compared with those inserted via a direct anterior approach. No stem revisions occurred in the posterior approach group or the lateral approach group, and 5 stems were revised in the anterior approach group for periprosthetic fracture or aseptic loosening (0.8%). Significantly more stem revisions occurred after the use of the new stem design and a direct anterior approach (P=.04). [Orthopedics. 2016; 39(1):e86-e92.]

Many surgical approaches for total hip arthroplasty (THA) have been described. Historically, the most common approaches used for THA have been the posterior and direct lateral approaches. The relative advantages of these approaches have been widely debated. Over the last decade, the popularity of the direct anterior approach for THA has increased. This intermuscular and internervous interval has a long history but recently has been facilitated by the development of instruments and implants that allow the procedure to be performed reproducibly. Recent reports comparing the direct anterior approach with either the posterior approach or the lateral approach showed that patients undergoing the direct anterior approach can have less pain and accelerated functional recovery in the early postoperative period.

At the authors’ institution, in an effort to take advantage of these proposed benefits, 1 surgeon underwent training and converted from using either the posterior approach or the lateral approach to using the direct anterior approach. In the 6 years before this conversion, the vast majority of primary THAs were performed with 1 of 2 cementless femoral stem designs (AML; DePuy, Warsaw, Indiana; Summit; DePuy), each with a well-documented track record. Because the design of these stems is relatively long and straight, they are not ideal for routine insertion through the direct anterior approach. Therefore, while converting to the direct anterior approach, the surgeon began to use a stem with a short, tapered-wedge design and a shoulder cutout to facilitate insertion (Tri-Lock New Approach and Stem Increased Femoral Revision Rate in Total Hip Arthroplasty Phonthakorn Panichkul, MD; Nancy L. Parks, MS; Henry Ho, MS; Robert H. Hopper Jr, PhD; William G. Hamilton, MD

The authors are from the Anderson Orthopaedic Research Institute, Alexandria, Virginia.

Dr Panichkul, Ms Parks, Mr Ho, and Dr Hopper have no relevant financial relationships to disclose. Dr Hamilton is a paid consultant for DePuy.

Correspondence should be addressed to: Nancy L. Parks, MS, Anderson Orthopaedic Research Institute, PO Box 7088, Alexandria, VA 22030 (narks@aori.org).

Received: November 13, 2014; Accepted: June 8, 2015.

doi: 10.3928/01477447-20151222-06
Bone Preservation Stem [Tri-Lock BPS; DePuy). This stem can be inserted with a hand-broaching technique, and the offset broaches are well suited to the anterior approach.

Numerous variations of stem designs have been introduced for the direct anterior approach and have shown excellent survival during the past decade. However, it is unclear whether these stems will perform equally well. Some stem designs have shown very high success rates, with survival ranging from 98% to 100% at 10-year follow-up. Despite excellent midterm results, a few recent reports raised concerns that other stems did not achieve osseointegration and went on to migrate. Subsidence of a femoral stem may predict failure in the long term and may affect clinical function and long-term survival.

Follow-up of patients who underwent implantation with the tapered-wedge stem design through the direct anterior approach showed a new and previously unseen rate of stem failure. The goal of this study was to compare revision and loosening rates of stems inserted with a posterior approach or a lateral approach with those of a new stem design inserted through a direct anterior approach.

**Materials and Methods**

Institutional review board approval was obtained for this retrospective database review that evaluated primary THAs performed by a single surgeon between 2003 and 2012. Eligible subjects included those who had undergone primary THA performed by a single fellowship-trained surgeon (W.G.H.). Inclusion criteria were (1) elective primary THA without previous fracture and (2) femoral fixation with 1 of 3 cementless stems: an extensively coated stem (AML or Prodigy, DePuy), a dual-tapered stem (Summit), and a single tapered-wedge stem (Tri-Lock BPS).

From 2003 to 2012, a total of 1108 THAs in 995 patients were analyzed. Medical records were reviewed for basic demographic data. Of these patients, 412 were men (41%) and 583 were women (59%). Mean patient age at the time of surgery was 63.0 years (range, 24-93 years), and mean body mass index was 28.6 kg/m² (range, 14.5-55.2 kg/m²). Mean duration of follow-up was 2.4±2.1 years (range, 0-10 years).

A posterior or lateral approach (n=514) was used to insert stems of 2 designs; an extensively coated cobalt-chrome cylindrical stem (AML or Prodigy) (n=232) or a straight, dual-tapered, proximally porous-coated titanium stem (Summit) (n=282). When the surgeon converted to a direct anterior approach using a fracture table (Hana Orthopedic Surgery Table; Mizuho OSI, Union City, California) in 2009, he began using a short, proximally coated, tapered-wedge titanium stem (Tri-Lock BPS). All direct anterior THAs were performed with intraoperative fluoroscopy to minimize suboptimal stem and cup positioning. In the direct anterior approach group, 594 stems were inserted between 2009 and 2012 (Table 1).

For all patients in both groups, a standardized protocol was used throughout the preoperative, perioperative, and postoperative course. The patients in the posterior approach group had posterior hip precautions, and those in the lateral approach group had anterior hip precautions to prevent dislocation. The postoperative rehabilitation program was weight bearing as tolerated, with restricted activity. Conversely, the direct anterior approach group had no postoperative restrictions and more aggressive weight bearing; assistive devices were discontinued as tolerated.

The institutional database was queried to identify all stem revisions performed among the primary THAs included in the study population, and the radiographic status of the femoral components was analyzed. A radiographic review was performed independently by 1 physician (P.P.) who was not involved in surgery. Anteroposterior radiographs and lateral cross-table radiographs of the hip were evaluated for stem subsidence and radiographic

![Table 1](image_url)
changes after surgery. Anteroposterior pelvic radiographs were taken with the beam centered on the pubic symphysis while the patient was supine with the legs internally rotated.

The position of the femoral component was evaluated with a fixed point of reference for the prosthesis, greater trochanter, and lesser trochanter. Subsidence was defined as settling of the femoral stem of more than 3 mm. With the use of a system previously described by Engh et al., femoral stem stability was classified into 1 of 3 categories: (1) stable bone ingrown; (2) stable fibrous ingrown (possibly loose); and (3) unstable (definitely loose).

Data were transferred to SPSS for Windows (IBM Corp, Armonk, New York) for statistical analysis. Continuous variables were analyzed with an unpaired Student’s t test to compare means and standard deviations. Categorical variables were assessed with Fisher’s exact test. Kaplan-Meier survival analyses were used to evaluate the cumulative prosthetic survival of each group. The end point was stem revision for any reason. A log-rank test was performed to compare the groups. The level of statistical significance was set at \( P<.05 \).

### RESULTS

Of the 514 stems inserted through either the posterior or the lateral approach, no stem revisions occurred. Seven stems were classified on radiographs as possibly (4 stems) or definitely loose (3 stems). Of those, 6 stem procedures (5 Prodigy and 1 AML) were performed through a posterior approach, and 1 Summit stem procedure was performed through a lateral approach (Table 2). Failure to osseointegrate occurred in 1.4% (7/514) of this group. Mean stem length was 149.8 mm.

Of the 594 short, tapered-wedge titanium stems inserted via the direct anterior approach, 5 stems were revised (0.8%), 2 for periprosthetic fracture (Figure 1) and 3 for aseptic loosening (Figure 2). There was a statistically higher rate of stem revision using the short, tapered-

---

**Table 2**

Revision Rate, Radiographic Data, and Stem Survival With Two Surgical Approaches

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Posterior and Lateral Approach</th>
<th>Anterior Approach</th>
<th>( P )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cases, No.</td>
<td>514</td>
<td>594</td>
<td></td>
</tr>
<tr>
<td>Stem revision, No. (%)</td>
<td>0 (0)</td>
<td>5 (0.8)</td>
<td>.04</td>
</tr>
<tr>
<td>Aseptic loosening</td>
<td>0</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Periprosthetic fracture</td>
<td>0</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Radiographic loosening, No. (%)</td>
<td>7 (1.4)</td>
<td>16 (2.7)</td>
<td>.09</td>
</tr>
<tr>
<td>Definite</td>
<td>3</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Possible</td>
<td>4</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Stem survival at 3-y follow-up</td>
<td>100.00%</td>
<td>98.4% (96.7%-100% at 95% confidence interval)</td>
<td>.03</td>
</tr>
</tbody>
</table>

---

**Figure 1**: Anteroposterior radiograph of the left hip of a 64-year-old woman 1 month after primary total hip arthroplasty performed through a direct anterior approach with a short tapered-wedge stem showing a periprosthetic fracture of the proximal femur (arrow). The medial calcar is completely broken and displaced. The stem has subsided substantially (A). Anteroposterior radiograph after revision shows a well-positioned tapered modular stem. The bone appears to be well healed at the area of periprosthetic fracture (B).
wedge titanium stem through the direct anterior approach \( (P=.04) \). In this group, 16 stems were classified on radiographs as possibly (14 stems) or definitely loose (2 stems) (Table 2). Osseointegration was not achieved in 2.7% (16/594) of cases. Mean stem length was 102.3 mm. At 3 years, stem survival in the direct anterior approach group was 98.4% (96.7%-100% at 95% confidence interval), which was significantly less than the 100% stem survival rate in the posterior and lateral approach groups \( (P=.03) \).

**Discussion**

To the authors’ knowledge, no published articles have directly addressed the effect of changing the surgical approach on the stem revision rate. The current results showed that the short, tapered-wedge titanium stem implanted through the direct anterior approach had a higher rate of stem revision and a trend toward a lower rate of osseointegration. The authors hypothesized 1 or more possible causes for this finding, including stem design, femoral visualization, postoperative mobilization, and surgeon experience. The stem has a relatively broad mediolateral dimension, a narrow anteroposterior dimension, and a distal taper. This short, tapered stem is designed to engage metaphyseal cortical bone in the mediolateral plane. Fixation is achieved in the metaphyseal region and relies on the concept of a rectangular wedge in an ovoid femoral canal or 3-point fixation along the stem length.\(^{15,30,31}\) The original Tri-Lock hip stem has been in clinical use since 1981, with excellent long-term survival and a low complication rate.\(^{30,32-35}\) A modified version of the Tri-Lock stem, the Tri-Lock BPS, was released in 2008, with a design goal of preserving proximal femoral bone stock and facilitating implantation. This new stem design was shorter, with a narrower distal segment and a flat, tapered wedge, and the material was changed to titanium alloy. With less porous coating, this design may have less inherent stability and may lead to subsequent failure of bone ingrowth. Each stem design has different features that may affect clinical outcomes.

Several studies have reported subsidence of tapered-wedge femoral stems in primary THA.\(^{22,26,27,36-38}\) Subsidence of cementless femoral stems has been associated with poor initial fixation. Robinson et al\(^{36}\) recently reported subsidence of tapered-wedge stems 6 weeks postoperatively in 10 of 264 hips (3.8%) and an associated transient decline in clinical function. Cooper et al\(^{22}\) retrospectively reviewed proximally coated tapered-wedge stems in primary THA and found that 15 of 320 stems (4.7%) did not achieve osseointegration. In the current study, this problem occurred in 2.7% of cases (16/594) in the direct anterior approach group, and 5 cases required revision. No revisions occurred in the posterior approach group or the lateral approach group.

Osseointegration failure of this type of stem is an uncommon but potentially serious complication that may require revision surgery. Several predisposing risk factors for osseointegration failure have been reported, including male sex, larger stem size, mismatch between the patient’s proximal femoral geometry and the stem, a smaller canal–flare index, greater canal fill at the mid- and distal thirds of the stem, and the rehabilitation program.\(^{22,26,36,37}\) When proximal–distal mismatch occurs, the stem may engage only distally on the cortical bone of the distal metaphysis–proximal diaphysis and may not achieve proximal osseointegration. In this situation, proximally coated stems do not have sufficient cortical contact to accomplish normal bone ingrowth as designed.

Weight bearing is another factor that has increased stem subsidence in the first 6 weeks after surgery for single- and double-tapered femoral stems. Rao et al\(^{35}\) compared a group of 28 patients undergoing unilateral hip arthroplasty who had...
10% weight bearing for 6 weeks with a group of 14 patients undergoing bilateral hip arthroplasty (28 hips) who were allowed unrestricted weight bearing. All patients received an uncemented tapered-wedge stem. The group with 10% weight bearing showed marginally less early subsidence at 6 weeks and overall less subsidence at 2 years.

Postoperative protocols for the direct anterior approach have evolved to emphasize rapid recovery as a result of minimal soft tissue trauma. Patients in the direct anterior approach group were allowed to bear weight as tolerated and had a more aggressive rehabilitation protocol, and assistive devices were discontinued as tolerated. Patients were given no hip precautions and were encouraged to progress with activities as tolerated. The multimodal pain control program also improved over time, allowing shorter length of stay and faster mobilization, and this may have contributed to a higher loosening rate in the direct anterior approach group. Unrestricted weight bearing can result in micromotion at the bone–implant interface, threatening stability and implant ingrowth for a cementless stem. Younger, active, heavier male patients place increased stress on the tapered-wedge stem and show increased subsidence after surgery.26,39 These patients may place excessive demands on their hips and require prolonged use of assistive devices to protect the treated hip in the early postoperative period. In contrast, immediate weight bearing after surgery with fully porous-coated (AML) femoral stems and CLS stems (Zimmer, Warsaw, Indiana) resulted in excellent clinical outcomes and stability.40-43

The risk of periprosthetic fracture is a potential disadvantage of a tapered-wedge femoral stem. Fracture may occur as a result of filling the proximal femur with the wedge-shaped implant or as a result of the hand-broached preparation technique that is necessary to achieve a tight press-fit for immediate stem stability. In the current series, 2 femoral fractures occurred with this type of stem. The reported 0.3% incidence of periprosthetic fracture with the tapered-wedge stem is comparable to other reports that ranged from 0% to 0.3%.26,38,44 Parvizi et al45 reported a concern about proximal femur fractures in Dorr type C femurs, which have loss of the taper and a thin cortex, requiring larger implants to achieve a good metaphyseal fit. There appears to be an association between early postoperative fracture and femoral geometry. However, periprosthetic fracture is minimized in a properly implanted stem.46 An accelerated postoperative rehabilitation protocol has also been suggested as a reason for the increasing prevalence of periprosthetic fractures.47

Protected weight bearing in the first few weeks may encourage a good long-term result by preventing this complication.

Another possible cause of loosening is that the new approach contributed to suboptimal placement and positioning of the stem. Woolson et al48 reported increased complications and femoral revisions with the anterior approach associated with early surgical experience. Of all of the approaches, the direct anterior approach is probably the most physiologic because the interval is truly intermuscular. It allows optimal muscle preservation and has gained popularity in recent years as a less invasive approach for THA.11,49 However, visualization with the anterior approach is limited because of muscle preservation that may cause suboptimal placement of the stem. Exposing the femur for reconstruction can be difficult, especially in patients with a short, varus angulated femoral neck.50 A special traction table has been advocated to enhance visualization of the femur and facilitate delivery of the stem. Intraoperative fluoroscopy can also be used to improve the accuracy of cup and stem placement49 and was used in the current direct anterior approach group.

The results of this retrospective review cannot be generalized to other cementless stem designs used with the direct anterior approach. The strengths of this study include a large number of patients and the fact that all procedures were performed by a single surgeon who used a consistent implantation technique for femoral stem placement. To remove potential surgeon bias, an orthopedic surgeon who was not otherwise involved in the surgery performed the radiologic analysis. The authors believe that this study provides useful clinical results for a short, tapered-wedge titanium stem inserted through the direct anterior approach.

CONCLUSION

More stem revisions were observed after the surgical approach and stem design were changed. There was a statistically higher rate of revision with the short, tapered-wedge titanium stem inserted through the direct anterior approach. However, it is unknown whether the stem design, femoral visualization, or postoperative mobilization was responsible for this trend. Caution is recommended when changing various aspects of techniques and implants simultaneously.

REFERENCES

6. Downing ND, Clark DI, Hutchinson JW, Colclough K, Howard PW. Hip abductor strength


