Early perioperative complication rates and subsidence with the Tribute[®] short cementless, tapered stem in primary total hip arthroplasty

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ABSTRACT

This study examined early perioperative complications and subsidence following total hip arthroplasty (THA) with a short femoral stem. A retrospective review of 207 consecutive patients (247 hips) having undergone THA via the direct anterior approach produced only six perioperative complications: two intraoperative fractures, three perioperative femur fractures and one dislocation. Subsidence greater than 5 mm was observed in four hips but subsidence did not progress greater than 3 mm at the latest follow-up. Based on these results, cementless THA through the direct anterior approach with a short femoral stem provides a clinical and radiographic advantage while maintaining low complication rates.

1. Introduction

Cementless femoral fixation during total hip arthroplasty (THA) is most commonly used in North America^{1,2} and has been shown to decrease pain and improve function.^{3–6} However, issues with stress shielding, non-ideal load transfer, thigh pain and periprosthetic fracture may occur.^{7,8} Short femoral cementless stems have recently become more popular. Theoretical benefits of short stem implants include preservation of bone stock, optimization of proximal load transfer, decreased stress shielding, and less diaphyseal stimulation which reduces the incidence of thigh pain^{8–15}.

The direct anterior approach (DAA) has gained popularity over the past decade. Proponents of this intermuscular approach cite preservation of abductor musculature and posterior capsule for allowing quicker recovery, decreased lengths of hospital stay, decreased dislocation rates, and more accurate component positioning. Furthermore, equalization of hip offset and leg lengths are facilitated with the use of intraoperative fluoroscopy. However, femoral exposure with the DAA can be challenging and inadequate exposure may contribute to increased risk of periprosthetic fracture, particularly during the initial learning curve. Shorter femoral implants are designed for easier insertion through a tissue-sparing approach and allow for broach-only femoral preparation.^{8,9} The short, proximal fit stem also avoids proximal to distal femoral mismatch commonly seen in younger patients with Dorr

type A femora.^{16,17} This often eliminates the need for reaming which is known to increase the risk of periprosthetic fractures when using standard length stems.^{12,18–20} Shorter stems may help to avoid femoral perforation in osteoporotic Dorr type C femora.¹⁴

Short femoral stems include several variations and continue to evolve. In this cohort, all patients underwent primary THA with a recently available short cementless, mediolateral (ML) tapered proximally plasma coated femoral implant (Tribute[®], Ortho Development, USA). This stem would be classified as Type 4 according to Khanuja et al.²¹ The stem is essentially a shorter ML taper type stem with a shortened, narrowed distal tip. It has the same proximal dimensions as the standard-length ML taper predecessor (Ovation[®], Ortho Development; Draper, UT). Therefore, it is fully interchangeable if a longer tapered stem is felt to be needed during intraoperative evaluation.

The purpose of this study is simply to report our early clinical experience regarding perioperative complications encountered in the first year and to report the incidence of radiographic evidence of subsidence with the use of a new, short, proximally porous coated, ML taper stem (Tribute[®], Ortho Development; Draper, UT) in a large high volume single surgeon series of THAs performed using the DAA.

2. Methods

An IRB approved retrospective study was performed including

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patients with symptomatic hip osteoarthritis who underwent THA using a DAA by a single, fellowship trained high volume arthroplasty surgeon from 2014 to 2016. Patients with traumatic femoral neck fractures, neuromuscular disease, sensorimotor deficiencies, or active infection were excluded. All THAs were performed using the same cementless implants: Tribute® femoral stem, Escalade® acetabular shell (Ortho Development; Draper, UT), Escalade® polyethylene insert (Ortho Development; Draper, UT), and BIOLOX® Delta (CeramTec, Plochingen, Germany) ceramic femoral head. Octogenarians or patients known to have osteopenia were not excluded from receiving these implants.

Patients were seen at two weeks, six weeks, three months, six months, one year and two years postoperatively. Besides intraoperative fluoroscopy, immediate postoperative supine anteroposterior pelvis radiographs were taken in the recovery room. Standing weight bearing anteroposterior pelvis and frog leg lateral x-rays were obtained from all patients at the six week follow up appointment and at six months, one year and two years following surgery. Demographic data gathered at the time of surgery included age, sex, body mass index, Dorr type femora and ASA category. Surgical and perioperative data were reviewed for operative time (defined as wheels into and wheels out of operative suite), intraoperative blood loss, incidence of transfusions, length of hospital stay, and discharge disposition. All pertinent perioperative complications were also recorded.

2.1. Radiographic methods

Standing weight bearing radiographs of the pelvis were evaluated for alignment and stability by two independent evaluators. Subsidence was determined by measuring the change in the perpendicular distance from the tip of the greater trochanter to the apex of the prosthesis (Fig. 1).²² All images and measurements were performed using the Picture Archiving and Communication Systems (PACS) software (Synapse® v. 3.1.1., Fujifilm Medical Systems U.S.A., Inc., Stamford, CT). If a measurement difference of greater than 5 mm was recorded, the prosthesis was considered to have subsided.²³ The morphology of the femoral canal was also assessed according to the Dorr classification system.¹⁶

2.2. Surgical technique

All patients received a preoperative paravertebral block, multimodal pain management protocol, prophylactic antibiotics, intravenous tranexamic acid before incision and during wound closure, and routine postoperative thromboembolic prophylaxis with aspirin 325 mg or lovenox as determined by risk or inability to tolerate non-steroidal chemoprophylaxis. The DAA was used in all hips and performed at a single multispecialty community institution by the same fellowship trained joint reconstruction surgeon. The DAA was performed utilizing

Fig. 1. Subsidence measurement perpendicular distance from the tip of the greater trochanter to the apex of the prosthesis distance.

a specialized orthopaedic fracture table (HANA®, Mizuho OSI; Union City, CA). A broach-only technique was used in all patients using a single offset broach handle. All patients received a BIOLOX® delta ceramic head. Reaming, cup insertion, and assessment of femoral broach position, fit and alignment was assessed with intraoperative fluoroscopy. For single stage bilateral THA, the first hip was completed and dressed prior to repositioning, redraping and opening of new sterile sets for performing the contralateral hip replacement.

All patients in both groups underwent the same postoperative protocol. Postoperative physical therapy and mobilization began the day of surgery. Immediate weight bearing was allowed for all patients. Patients were discharged when assessed to be medically stable and independently capable for safe return to home environment. Patients unable to function safely or care for themselves independently were transferred to an inpatient acute rehabilitation facility if necessary prior to discharge home.

2.3. Statistical analysis

Descriptive statistics, including mean, standard deviation and range, were determined for pertinent patient demographics. Descriptive statistics were also created for perioperative variables.

3. Results

Patient demographics (Table 1) for 207 patients (247 hips) fitting the inclusion criteria were determined as (mean ± standard deviation): male = 101; age, 65.6 ± 10.5 years; body mass index, 27.0 ± 5.2. Patients' ASA categories comprised of: category one included two patients, category two included 109 patients, category three included 95 patients, and category four included one patient. Dorr classification was grouped by number of hips, resulting in: Dorr A – 45 hips; Dorr B – 165 hips; Dorr C – 37 hips. Perioperative variables (Table 2) were determined as (mean ± standard deviation): total operating time: 96.4 ± 46.2 min; estimated blood loss: 278.62 ± 111.9 cc; length of stay: 2.1 ± 0.9 days; discharge disposition: 176 patients went home, 25 patients discharged to a rehabilitation hospital and six patients discharged to a skilled nursing facility. Twenty-three patients received a blood transfusions, 12 of which underwent bilateral THA.

Table 1
Demographic information.

	n = 207 patients
	Mean ± SD
Age	65.6 ± 10.5
BMI	27 ± 5.2
Hips	n = 207 patients
Bilateral	40
Unilateral	167
Dorr Type	n = 247 hips
Type A	45
Type B	165
Type C	37
ASA Grade	n = 207 patients
1	2
2	109
3	95
4	1

n = number of patients or hips.

SD = standard deviation.

BMI = body mass index.

ASA = anesthesiologist classification.

Table 2
Descriptive surgical outcomes.

	Mean $\pm$ SD
ORT (min)	96.4 $\pm$ 46.2
LOS (days)	2.2 $\pm$ 0.9
EBL (cc)	278.6 $\pm$ 111.9
Hemoglobin	
Pre-op	13.9 $\pm$ 1.4
Discharge	10.8 $\pm$ 1.5
Hematocrit	
Pre-op	41.4 $\pm$ 4.0
Discharge	40.0 $\pm$ 4.2
Home Discharge	85.0%
Transfusion	11.2%

SD = standard deviation.

ORT = operating room time.

min = minutes; LOS = length of hospital stay.

EBL = estimated blood loss.

cc = cubic centimeters.

The mean subsidence at six weeks post-operative was 1.6 ± 1.9 mm (range 0–16.3 mm). Radiographic evidence of subsidence greater than 5 mm was observed in four hips, measured at 6.1 mm, 7.9 mm, 9.8 mm, and 16.3 mm. No further progression of subsidence greater than 3 mm was observed in these four patients at the latest follow up (range six to 27 months).

Of the 247 hips, only six perioperative complications were present (Table 3). Two intraoperative fractures occurred, with one patient sustaining a calcar fracture during stem insertion, treated with a cerclage cable, and one sustained a superior pubic rami fracture found on a post-operative radiograph, requiring no change in postoperative protocol. Three perioperative femur fractures occurred. One sustained a spiral fracture around the implant after falling out of bed. Two patients sustained fractures with no mechanism of injury, reported one and three days post-operatively. All perioperative femur fractures required open reduction, internal fixation with a revision of the femoral stem (Fig. 2). One patient sustained an anterior hip dislocation five months post-operatively during yoga class, when the patients' leg was forced into extreme abduction by the yoga instructor. The hip was reduced successfully without subsequent dislocation.

4. Discussion

The purpose of this study was to report our intraoperative and early postoperative complications potentially related to a newly available stem with design specifications identical to the classic ML taper type stem with the exception of a shorter, narrowed distal half. This stem was specifically designed for easier insertion through a DAA and to avoid problems of proximal-distal mismatch common for longer stems. While designed for the anterior approach, this stem should feel familiar to all surgeons comfortable with ML taper type stems. This initial cohort of patients represents the first consecutive series of cases utilizing the Tribute® short femoral stem for DAA THA performed by the senior surgeon.

Table 3
Complication descriptives.

Patient	Complication	Procedure	Gender	Age	BMI	Dorr	Location	Comorbidity	Treatment
1	Intraoperative	Bilateral	Female	86	21.8	C	Right calcar fracture during implantation	Osteoporosis	Cerclage Cable
2	Intraoperative	Unilateral	Female	57	27.5	B	Superior pubic rami fracture	N/A	TTWB for 4 weeks
3	Perioperative	Unilateral	Female	83	27.3	B	Subtrochanteric Fracture	Osteopenia	ORIF; Femoral stem revision
4	Perioperative	Unilateral	Female	73	20.8	B	Femur Fracture	Osteoporosis	ORIF; Femoral stem revision
5	Perioperative	Bilateral	Female	76	24.2	B	Right femur fracture	Osteoporosis	ORIF; Femoral stem revision
6	Dislocation	Unilateral	Female	54	17.7	C	Anterior Dislocation	Osteoporosis	Reduced, No treatment required

BMI = body mass index; Dorr = bone classification; TTWB = toe touch weight bearing; ORIF = open reduction, internal fixation.

Fig. 2. Early postoperative fracture during routing physical therapy session. Treated with ORIF and revision of the stem thru an extended anterior approach.

Femoral exposure using the DAA is known to be challenging even for experienced surgeons. A systematic review of nearly 12,000 THAs performed reported a 2.3% incidence of periprosthetic femur fractures with this approach.²⁴ Shorter stems are designed for easier insertion with less femoral preparation. In our present study, the rates of intraoperative fracture and postoperative periprosthetic fracture were each 0.8%. These rates are consistent with previously reported rates for THA via the DAA using short stem femoral implants which range from 0 to 1.6%.^{8,9,25} Molli et al. reported a periprosthetic fracture rate of 0.4% with the TaperLoc® Microplasty™ short stem compared to 3.1% with a standard-length stem, using a combination of approaches including 19% DAA, 71% minimally invasive lateral approach and 10% direct lateral approach.⁸ Similarly, Dietrich et al. reported a 1.6% fracture rate with use of the Fitmore® and AMIStem® short stems compared to 6.8% for standard length stems.⁹ Unlike the other studies, Berend et al. reported a periprosthetic fracture rate of 1.1% with the short TaperLoc stem compared to 0.6% with the standard-length stem.²⁵ Tamaki et al. reported a 2.0% rate of perioperative fractures with short stems placed via the DAA, but 88% of those patients underwent THA for developmental dysplasia of the hip.²⁶ The authors acknowledged that short stems are a good option for patients with good bone quality and without dysplastic hips. All surgeons in each study were experienced with the DAA and beyond the initial learning curve²⁷ therefore inexperience or lack of technical proficiency can be reasonably excluded as a source for failure.

The lower intraoperative fracture rate with shorter stems may be due to better avoidance of proximal-distal mismatch which reduces the need to ream the femoral canal in young, robust Dorr A femora. Short stems may also help avoid diaphyseal perforation by allowing the surgeon to obtain a more anatomical broaching insertion vector. Longer

stems tend to force a surgeons hand anteriorly, risking lateral femoral perforation. Shorter stems also tend to fit well proximally even in excessively bowed femurs or other femoral diaphyseal deformities. One of the intraoperative fractures that occurred was in a Dorr C type femur in an 86 year old female. She sustained a non-displaced calcar fracture during implantation of the femoral implant. The other presumed intraoperative fracture was in a Dorr B type femur in an 83 year old female with osteoporosis. On postoperative day three, this patient was found to have a nondisplaced subtrochanteric fracture after she developed pain while full weight bearing during a physical therapy session. This may have been a fracture that occurred intraoperatively which was not recognized. Both patients were over 80 years old, female, and osteoporotic. These factors are known to be significant risk factors for periprosthetic femur fractures in primary THA.^{28,29} It is important to avoid intraoperative fractures since it has been shown to have a three fold higher incidence of overall failure in the first six months in patients that sustain an intraoperative femoral fracture.³⁰

The radiographic analysis revealed a subsidence rate of 1.6% at six weeks. There were no correlations to age, BMI, Dorr classification, or presence of pain. We presume the majority of subsidence to occur by six weeks as the implant begins to settle in. Other authors have also described subsidence only occurring in the first month postoperatively as well.³⁵ The rate of subsidence observed in this cohort is comparable to reported rates of subsidence for short femoral stems. Ulivi et al. reported 4.3% (7/163) subsidence rate, albeit they used a threshold of 3 mm.³¹ Patel et al. reported no subsidence in two of his series with a combined total of 129 hips.^{32,33} The ML tapered design of the stem allows the stem to achieve a wedge fit at the metaphysis without the need for an interference fit in the diaphysis. Short stems also retain the shoulder and lateral flare component which allow for lateral column support to prevent subsidence.³⁴ In our series, we observed a small amount of movement in the early postoperative period in a small number of patients. There were no symptomatic complications in these patients and none of them continued to subside greater than 3 mm beyond six weeks. However, longer term follow up is needed to determine rates of failure and aseptic loosening. Another proposed mechanism responsible for initial subsidence and potential failure is the creation of an anterior metaphyseal gap caused by non-linear broaching trajectory when utilizing the DAA. This can lead to a cascade of instability, subsidence, distal potting, and eventual loosening.³⁶ Again, shorter metaphyseal fitting stems may help decrease these occurrences by avoiding diaphyseal engagement and allowing for improved broaching techniques when femoral exposure is challenging.

Short stems theoretically limit thigh pain. In our study, the rate of thigh pain was reported at 2% which resolved by one year. This is consistent with prior reports of thigh pain with the use of short femoral stems ranging from 0 to 4%.^{37–42} However, these studies are not directly comparable because they did not use the DAA. Additional clinical outcomes data are needed to further characterize pain and reasonably comment on functional differences.

Our study does have several limitations. There is no control or direct comparison group so comparisons were made to previously reported results in the literature. The purpose of this study was to report our intraoperative and early postoperative complications potentially related to a newly available stem. We did not include clinical outcomes data, and do not imply or suggest that this stem has any clinical advantage over other stem designs. We are simply trying to compare safety of this stem regarding early clinical experience and to determine if in its early use has shown to have any negative outcomes that can be reasonably attributed to the stem alone. The strength of this study is that it represents a relatively large consecutively performed cohort of THAs performed by a single experienced, high volume community hospital surgeon. During this time period, surgical technique was consistent, no fellows or residents were involved and postoperative patient care was uniform. Furthermore we did not exclude any patient from receiving these implants. Age greater than eighty and osteopenia were

not excluded.

5. Conclusions

In this consecutive series of patients undergoing THA via the DAA with the Tribute® femoral stem, there was a low incidence of intraoperative and perioperative complications. A 0.8% rate of intraoperative fracture and 0.8% incidence of postoperative femur fractures is comparable with previously reported rates for short stem implants and less than standard length stems. While the two postoperative fractures were due to patient falls, we included them as complications since the stem may have had an impact on producing the fall or the fracture type. Subsidence rates were minimal at 1.6% and did not progress or lead to early failure. However, longer term follow up and clinical outcome measures are needed to provide a comprehensive evaluation of survivorship and durability to assess whether specific short femoral stem implants provide clinical and radiographic advantages while achieving equivalent or lower complication rates.

Conflicts of interest

There are two conflicts of interest to declare:

Dr. Andrews reports personal fees from Ortho Development, outside the submitted work.

Dr. Nakasone reports personal fees from Ortho Development, during the conduct of the study; personal fees from Ortho Development, outside the submitted work.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jor.2019.01.002>.

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