Major complications after total hip arthroplasty with the direct anterior approach at a high-volume Ontario tertiary care centre

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Background: The rate of major surgical complications for high-volume orthopedic surgeons using the direct anterior approach (DAA) in Ontario, Canada, is not known. The purpose of this study was to investigate the rate of major surgical complications after total hip arthroplasty (THA) using DAA performed by experienced orthopedic surgeons at a high-volume tertiary care centre in Ontario.

Methods: We conducted a retrospective cohort review of primary THA through DAA performed by 2 experienced fellowship-trained surgeons at an academic hospital in London, Ontario, between Jan. 1, 2012, and May 1, 2019. We excluded the first 100 cases to allow for surgeon learning curves. We recorded major surgical complications (intraoperative events, postoperative periprosthetic fractures, dislocation requiring closed or open reduction, implant failure [aseptic loosening or subsidence], early (< 6 wk) deep wound infection requiring irrigation and debridement, late (≥ 6 wk) deep wound infection requiring irrigation and debridement, and wound complications [wound dehiscence, stitch abscess, erythema, hematoma or seroma]) within 1 year of THA.

Results: A total of 875 primary DAA THA procedures were included. The rates of surgical complications were 0.9% for intraoperative events, 1.5% for postoperative periprosthetic fractures, 0.8% for implant failure, 0.7% for early deep wound infection, 0.1% for late deep wound infection and 3.2% for wound complications; there were no cases of dislocation. The rate of revision for implant failure within 1 year was 0.1%. Male sex was associated with a greater risk of implant failure (p = 0.01), and having a higher body mass index was associated with both increased rates of infection (p < 0.01) and having a wound complication (p < 0.01).

Conclusion: Intraoperative events, postoperative periprosthetic fractures, implant failure, deep wound infection and wound complications accounted for the major surgical complications within 1 year of THA through DAA. The low revision rate suggests that DAA is a safe approach for THA.
otal hip arthroplasty (THA) is an appropriate treatment option for severe hip osteoarthritis. It is one of the most reliable and reproducible procedures in orthopedic surgery, achieving a success rate as high as 97%. The direct anterior approach (DAA) has gained momentum as a favourable approach for THA, and numerous authors have reported accelerated early postoperative recovery, shorter rehabilitation times, more reliable acetabular alignment and lower risk of dislocation. Furthermore, other authors have reported a reduction in hospital length of stay when THA was performed through DAA, and this approach contributed significantly to an overall reduction in costs from a hospital perspective. However, recent literature has suggested that DAA leads to early revision rates as compared to other, more traditional approaches. Also, other authors have reported concerns about the safety of DAA, noting higher rates of wound complications, lateral femoral cutaneous nerve neuropraxia, heterotopic ossification and periprosthetic femur fracture. In a recent meta-analysis and systematic review, Jin and colleagues reported that, compared to the posterolateral approach, DAA was associated with a quicker functional recovery in older patients undergoing THA and was less invasive, with an earlier return to daily activities; however, the amount of postoperative drainage, length of incision, blood loss, length of hospital stay and postoperative bed time were similar between the 2 groups. Furthermore, the Harris Hip Score values at 1 month and 12 months postoperatively, and the incidence of lateral femoral cutaneous nerve neuropraxia were higher in the DAA group, yet fewer patients in the DAA group than in the posterolateral approach group had postoperative dislocation.

The authors of a retrospective multicentre cohort study conducted in the United States concluded that there was an acceptable complication profile with DAA, with a very low dislocation rate, early return to function and a decline in complications for surgeons with more than 100 case experiences. Furthermore, de Steiger and colleagues concluded that there was a learning curve for DAA, even with the use of a prosthesis combination specifically marketed for DAA.

In a population-based retrospective cohort study using the ICES database that included data from 73 hospitals and 298 orthopedic surgeons across Ontario, Pincus and colleagues found a small but statistically significant increased risk of major surgical complications among patients who underwent THA through DAA compared to a posterior or lateral surgical approach. The difference was attributable mainly to deep infection (1.2% v. 0.4%), dislocation (0.7% v. 0.3%) and revision surgery (1.2% v. 0.7%). However, those authors did not assess the learning curve and/or experience level of the orthopedic surgeons (volume of cases per surgeon at each hospital) using DAA. The vast majority of surgeons listed in the ICES database would still be “in” their learning curve. Bhandari and colleagues reported lower complication rates than Pincus and colleagues; therefore, their study was likely designed without adjustment for the learning curve. Canadian authors have reported that DAA in THA can be introduced into practice with an acceptable adverse event rate compared to other approaches to THA; as expected, the rate of adverse events was higher in the early part of the learning curve. Therefore, there is a need to understand the rate of major complications with DAA in THA to ensure best surgical practice.

Moreover, the rate of major surgical complications (intraoperative events, postoperative perioperative fractures, dislocation requiring closed or open reduction, implant failure [aseptic loosening or subsidence], early deep wound infection, late deep wound infection and wound complications [wound dehiscence, stitch abscess, erythema, hematoma, seroma]) among experienced, high-volume orthopedic surgeons using DAA in Ontario is not known. The purpose of this study was to investigate the rate of major surgical complications among patients undergoing THA through DAA performed by experienced surgeons. The specific aims were to determine the rate of major surgical complications within 1 year of THA and the associations between patient demographic and surgical factors (femoral stem implant type and anesthesia type), and major surgical complications within 1 year.

**Methods**

**Study design, setting and participants**

We conducted a retrospective cohort review of prospectively collected data for an observational cohort of all patients who underwent primary THA through DAA for osteoarthritis between Jan. 1, 2012, and May 1, 2019. All procedures were performed by 2 fellowship-trained surgeons with more than 27 years of experience in DAA THA at an academic hospital in London, Ontario, Canada. Data were extracted from an
electronic institutional database (OrthoTech). All patients who were followed for at least 1 year were included in the analysis. Ethics approval was received from the Western University Health Sciences Research Ethics Board (Institutional Review Board 00000940).

Data source

We extracted patient demographic characteristics (body mass index [BMI], sex, age) and comorbidities from our institutional database. To exclude any adverse events owing to surgeon learning curves, we excluded each surgeon’s first 100 cases.

All femoral stem implant types from Stryker (Accolade II, Anato and Exeter V40), Smith & Nephew (Anthology, Echelon, Polarstem and Synergy) and DePuy Synthes (Corail and Summit) were included, as were all acetabular cup implant types (Stryker Trident, Smith & Nephew R3 and DePuy Synthes Pinnacle). We also extracted the type of anesthesia administered (general anesthesia or combined spinal anesthesia with intravenous sedation with the patient in the supine position).

Primary outcome

The primary study outcome was the occurrence of a major surgical complication within 1 year of THA. We recorded the following major surgical complications: intraoperative event, postoperative periprosthetic fracture, dislocation requiring closed or open reduction, implant failure (aseptic loosening or subsidence), early deep wound infection (< 6 wk) requiring irrigation and débridement, late deep wound infection (≥ 6 wk) requiring irrigation and débridement, or wound complication (wound dehiscence, stitch abscess, erythema, hematoma or seroma). We classified intraoperative events as minor (nondisplaced to minimally displaced fracture of greater trochanter or calcar crack not requiring alteration in weight-bearing status) or major (moderately displaced greater trochanteric fracture, femoral shaft fracture or femoral shaft perforation).

Statistical analysis

We used descriptive statistics to summarize demographic data and reported rates of major surgical complications as a percentage. We used theχ² test to determine associations between nominal patient and surgical factors and major surgical complications. We used simple logistic regressions to determine associations between continuous patient and surgical factors (age, BMI) and major surgical complications. We used independent t tests to compare patient factors between patients who had no major surgical complications and those who had major surgical complications. To further identify predictors of major complications, we performed multivariable logistic regression analyses using major complications as the dependent variable. Only variables predictive of major complications in bivariate analyses (χ² test or simple logistic) were included in the logistic regression. We conducted statistical analysis using GraphPad Prism 9, and significance for all statistical tests was accepted at p ≤ 0.05.

Results

A total of 871 primary DAA THA procedures were included in the study. There were 460 females (52.8%) and 411 males (47.2%) with a mean age of 65.1 (SD 11.2) years and a mean BMI of 28.3 (SD 4.7) (Table 1).

The cumulative incidence of major surgical complications was 6.9% (n = 63) (Table 2), with the most frequent being wound complications (28 [3.2%], postoperative

Table 1. Demographic characteristics of patients and of major surgical complications

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean age ± SD, yr</th>
<th>Mean BMI ± SD</th>
<th>Sex, male:female</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>65.1 ± 11.2</td>
<td>28.3 ± 4.7</td>
<td>411:460</td>
</tr>
<tr>
<td>All complications</td>
<td>66.1 ± 11.5</td>
<td>30.2 ± 5.2</td>
<td>34:26*</td>
</tr>
<tr>
<td>Infection</td>
<td>68.9 ± 5.7</td>
<td>33.6 ± 5.2</td>
<td>4:3</td>
</tr>
<tr>
<td>Implant failure</td>
<td>65.8 ± 12.7</td>
<td>31.6 ± 3.8</td>
<td>7:0</td>
</tr>
<tr>
<td>Revision</td>
<td>70.9 ± 10.3</td>
<td>37.2 ± 3.6</td>
<td>1:0</td>
</tr>
<tr>
<td>Periprosthetic fracture</td>
<td>70.2 ± 11.6</td>
<td>27.5 ± 3.8</td>
<td>4:9</td>
</tr>
<tr>
<td>Wound complication</td>
<td>63.9 ± 12.7</td>
<td>30.8 ± 5.9</td>
<td>16:12</td>
</tr>
<tr>
<td>Intraoperative event</td>
<td>69.5 ± 9.8</td>
<td>25.5 ± 2.6</td>
<td>2:6</td>
</tr>
<tr>
<td>No complications</td>
<td>65.0 ± 11.2</td>
<td>28.2 ± 4.7</td>
<td>377:434</td>
</tr>
</tbody>
</table>

BMI = body mass index; SD = standard deviation.

*Some patients had more than 1 complication.

Table 2. Rate of major surgical complications

<table>
<thead>
<tr>
<th>Complication</th>
<th>No. (%) of events n = 63</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intraoperative event</td>
<td>8 (0.9)</td>
</tr>
<tr>
<td>Minor*</td>
<td>5 (0.6)</td>
</tr>
<tr>
<td>Major†</td>
<td>3 (0.3)</td>
</tr>
<tr>
<td>Postoperative periprosthetic fracture</td>
<td>13 (1.5)</td>
</tr>
<tr>
<td>Implant failure</td>
<td>7 (0.8)</td>
</tr>
<tr>
<td>Aseptic loosening</td>
<td>4 (0.5)</td>
</tr>
<tr>
<td>Subsidence</td>
<td>3 (0.5)</td>
</tr>
<tr>
<td>Revision owing to implant failure</td>
<td>1 (0.1)</td>
</tr>
<tr>
<td>Deep wound infection</td>
<td>7 (0.8)</td>
</tr>
<tr>
<td>Early</td>
<td>6 (0.7)</td>
</tr>
<tr>
<td>Late</td>
<td>1 (0.1)</td>
</tr>
<tr>
<td>Wound complication</td>
<td>28 (3.2)</td>
</tr>
<tr>
<td>Dehiscence</td>
<td>10 (1.1)</td>
</tr>
<tr>
<td>Stitch abscess</td>
<td>9 (1.0)</td>
</tr>
<tr>
<td>Erythema</td>
<td>2 (0.2)</td>
</tr>
<tr>
<td>Hematoma</td>
<td>5 (0.6)</td>
</tr>
<tr>
<td>Seroma</td>
<td>2 (0.2)</td>
</tr>
</tbody>
</table>

*Undisplaced to minimally displaced fracture of greater trochanter or calcar crack not requiring alteration in weight-bearing status.
†Moderately displaced greater trochanteric fracture, femoral shaft fracture or femoral shaft perforation.
periprosthetic fractures (13 [1.5%] and intraoperative events (8 [0.9%]). There were 7 instances (0.8%) of implant failure (aseptic loosening or subsidence), which required revision in 1 case. There were no dislocations.

Body mass index was significantly higher for patients who had a major complication than for those who did not (p = 0.02). Male sex was associated with a greater risk of implant failure (p = 0.01) (Table 3). Also, having a higher BMI was associated with increased rates of infection and having a wound complication (both p < 0.01). There were no differences in average age, anesthesia type or implant type between the 2 groups.

On logistic regression, BMI was significantly predictive of major surgical complications (odds ratio [OR] 1.09, 95% confidence interval [CI] 1.04–1.16), whereas sex was not (OR 1.29, 95% CI 0.75–2.25).

**DISCUSSION**

In this retrospective cohort review, the major surgical complications within 1 year of THA through DAA were intraoperative events (0.9%), postoperative periprosthetic fractures (1.5%), implant failure (0.8%), deep wound infections (0.8%) and wound complications (3.2%). The cumulative incidence of major surgical complications was 6.9%, and the rate of revision within 1 year was 0.1%. The 3 most frequent complications were wound complications (3.2%), postoperative periprosthetic fracture (1.5%) and intraoperative event (0.9%). Like previous authors, we found an increased risk of implant failure and revision among males. Not surprisingly, patients with a higher BMI had a higher rate of major complications, also consistent with previous literature.

We found a lower dislocation rate (0.0% v. 0.7%), a lower deep wound infection rate (0.8% v. 1.2%) and a lower rate of revision surgery within 1 year (0.9% v. 1.2%) than those reported in a study assessing the risk of major surgical complications in Ontario using the ICES database. A prospective study using the Australian Orthopaedic Association National Joint Replacement Registry showed that the most common reasons for revision within 4 years after primary DAA THA were fracture (0.6%), loosening (0.5%), dislocation (0.3%) and infection (0.3%). In a study comparing DAA to the lateral approach, the overall complication rate was significantly lower in the DAA group. The overall rates of fracture and early infection were comparable between the 2 groups, but the dislocation rate was significantly increased in the DAA group. The study authors concluded that DAA had short-term surgical complications comparable to those with the lateral approach, with reduced transfusion and general complication rates.

Orthopedic surgeons need to be aware of the effects of the learning curve on patient safety and surgical outcomes. A learning curve is defined as the relation between how proficient someone is at a task and the amount of experience they have. Graphically, a learning curve represents the relation between learning effort and learning outcome. Orthopedic surgeons’ experience and volume influence the result of hip arthroplasty. The learning curve may depend on surgeon experience, surgeon ability, surgical processes, volume of operations, a new technique or approach, or type of prosthesis. Goytia and colleagues evaluated the learning curve for DAA and concluded that orthopedic surgeons considering this approach should expect a substantial learning period. Adoption of DAA temporarily exposes patients to a higher risk of implant revision, which may be normalized after a certain number of cases, and experience from a single surgeon’s learning curve could effectively be taught to junior surgeons.

In their prospective study, de Steiger and colleagues assessed the minimum number of cases required to complete a learning curve for DAA within a 4-year period. They categorized 68 orthopedic surgeons into 5 groups according to the number of DAA operations they had performed: 1–15, 16–30, 31–50, 51–100 or more than 100. The cumulative percent revision at 4 years was 3%. However, not surprisingly, the cumulative percent revision for surgeons who had performed 15 procedures or fewer was 6%, compared to 2% for surgeons who had performed more than 100 procedures. It was not until the surgeon had performed more than 50 operations that there was no

| Table 3. Significance of associations for each complication |
| --- | --- | --- | --- | --- |
| Complication | Patient factor; p value* | Surgical factor; p value* |
| | Sex | Age | BMI | Anesthesia | Implant |
| Intraoperative event | 0.2 | 0.1 | 0.09 | 0.7 | 0.8 |
| Postoperative periprosthetic fracture | 0.2 | 0.1 | 0.6 | 0.6 | 1.0 |
| Implant failure | 0.01 | 0.3 | 0.1 | 0.7 | 0.3 |
| Revision | — | — | — | — | — |
| Infection | 0.6 | 0.4 | < 0.01 | 0.7 | 1.0 |
| Wound complication | 0.3 | 0.8 | < 0.01 | 0.5 | 0.1 |

BMI = body mass index.
*p value* for association between nominal patient and surgical factors and major surgical complications; simple logistic regression for association between continuous patient and surgical factors (age, BMI) and major surgical complications.
difference in the cumulative revision rate between this group and surgeons who had performed more than 100 operations. Those authors concluded that there is a learning curve for THA through DAA and that surgeons should be aware of this initial higher revision rate when deciding which approach delivers the best outcome for their patients. Ravi and colleagues\(^1\) reported that, under a threshold of 35 cases a year, there was an increased risk of dislocation and revision in first-time recipients of THA. In their retrospective cohort study that included 73 hospitals and 298 surgeons across Ontario, Pincus and colleagues\(^2\) found that, although patients who underwent THA with the anterior approach were treated by higher-volume surgeons than those who had the lateral or posterior approach, they had a significantly greater risk of a major surgical complication; however, those authors did not account for the learning curve. Our group in London has previously reported that there was no significant difference in revision rates between DAA and the direct lateral approach.\(^4\) Therefore, the increased risk of deep infection, dislocation and revision surgery through DAA compared to the posterior or lateral approach reported by Pincus and colleagues\(^5\) may have been due to surgeon learning curve, as excluding the first 35–100 cases, for example,\(^31,39,41,42\) may have mitigated some of these complications.

### Limitations

Because the data for this study were obtained from a retrospective database that relies on accurate record-keeping by people other than members of the research team, they may lack information on potential confounding factors. We included revisions only up to 1 year postoperatively, and patients who had short follow-up owing to distance from the site of the index procedure were excluded.

### CONCLUSION

The rates of major surgical complication among patients who underwent THA through DAA performed by experienced orthopedic surgeons at a high-volume Ontario tertiary care centre were 0.9% for intraoperative events (fracture), 1.5% for postoperative periprosthetic fractures, 0.0% for dislocation, 0.8% for implant failure (aseptic loosening or subsidence), 0.7% for early deep wound infection, 0.1% for late deep wound infection and 3.2% for wound complications. The cumulative incidence for return to the operating room for a major complication due to a deep wound infection or implant failure was 0.9%, and the rate of revision for implant failure within 1 year was 0.1%. The low revision rate suggests that DAA is a safe approach for THA.

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### Competing interests:

Kevin Boldt is Director, Professional, of the Canadian Society for Exercise Physiology. James Howard reports consulting/research support from DePuy Synthes, Intellijoint, Microport, Smith & Nephew, Stryker and Zimmer. Brent Lanting reports institutional support and project-specific grants from Smith & Nephew, Stryker, DePuy Synthes and Zimmer, and consulting/research support from DePuy Synthes, IdealFit Spaces Solutions, Intellijoint, Smith & Nephew, Stryker and Zimmer. No other competing interests were declared.

### Contributors:

K. Barton and B. Lanting designed the study, with contributions from L. Somerville, J. Howard and B. Lanting. K. Barton, N. Steiner, O. Sogbein and S. Tsioros acquired the data, which K. Barton, N. Steiner and K. Boldt analyzed, with contributions from L. Somerville, J. Howard and B. Lanting. K. Barton wrote the article, which N. Steiner, K. Boldt and O. Sogbein reviewed, with contributions from L. Somerville, J. Howard and B. Lanting. All authors approved the final version to be published.

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