Influence of surgical approach on complication risk in primary total hip arthroplasty

Systematic review and meta-analysis

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The durability of total hip arthroplasty (THA) is excellent with 10-year survivorship exceeding 90% (Haider et al. 2015, Makela et al. 2014). All standard approaches to the hip have been shown to be safe and effective, with certain advantages and disadvantages of each approach (Mjaaland et al. 2017). While the anterior approach (A) has been increasingly used in the United States, little is known about the safety of the A relative to other common surgical approaches. Several groups (Higgins et al. 2015, Meermans et al. 2017, Putananon et al. 2018) have performed systematic reviews comparing the A with the posterior approach (P) in primary THA. However, follow-up durations of the included studies varied widely, with most studies having less than 1-year follow-up. Comparative safety evaluation of these surgical techniques over a longer period is warranted. The purpose of this systematic review with meta-analysis was to compare the complication risk of A versus P in studies with at least 1-year mean follow-up.

Methods

Literature search and data extraction

In accordance with the PRISMA guidelines, we searched MEDLINE and EMBASE for comparative studies of primary THA performed using the A or P. Therapeutic search terms consisting of THA and total hip arthroplasty were combined with the following surgical approach-specific search terms: anterior, direct, posterior, posterolateral, and Smith-Petersen. We also manually searched the Directory of Open Access Journals (DOAJ), Google Scholar, and the reference lists of included papers and relevant systematic reviews. No language or date restrictions were applied to the searches. The final search was conducted on June 30, 2017.
Study eligibility was determined by 2 independent researchers (LM, DF). Disagreements were resolved by discussion. Main inclusion criteria included comparison of A versus P in primary THA, predominant diagnosis of osteoarthritis, mean follow-up duration at least 1 year, and extractable complication data. Titles and abstracts were initially screened to exclude review articles, commentaries, letters, case reports, and obviously irrelevant studies. Full-texts of the remaining articles were retrieved and reviewed. Studies were excluded if patients received revision or bilateral THA. When multiple studies included overlapping series of patients, only the study with the largest sample size was included. Data were independently extracted from eligible peer-reviewed articles by the same 2 researchers. Data discrepancies were resolved by discussion.

Definitions and outcomes

When data were reported at multiple intervals during follow-up, the final value was extracted for analysis. Complications included infection, dislocation, reoperation (for any reason), thromboembolic event, heterotopic ossification, wound complication, fracture, and nerve injury. To account for differential follow-up durations, complication data were extracted by determining the number of events and then calculating the number of person-years in each group to determine incidence rates. Risk of bias in each study was assessed with the Cochrane Collaboration tool, which included evaluations of sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting, and other sources of bias (Higgins et al. 2011).

Data analysis

We assumed heterogeneous effects among studies a priori and conservatively applied a random effects model for all outcomes. Denominators were adjusted to include the number of patients or hips, as appropriate. The rate ratio (RR) was the effect size statistic of interest, which indicates the ratio of incidence rates (events per person-year) between A and P. A RR value > 1 indicates higher complication incidence rate with A and a value < 1 indicates lower complication incidence rate with A. For each complication, the RR and 95% confidence interval (CI) were calculated in each study and pooled among all studies. Inconsistency in complication risk among studies was quantified with the I² statistic; values of ≤ 25%, 50%, and ≥ 75% represented low, moderate, and high inconsistency, respectively (Higgins et al. 2003). Publication bias was visually assessed with funnel plots (not shown) and quantitatively assessed using Egger’s regression test. Post hoc random effects meta-regression using the Knapp–Hartung method (Knapp and Hartung 2003) was performed to assess the possible influence of study design, median surgery year, inclusion of learning cases, and follow-up duration on complication risk. P-values were 2-sided with a significance level < 0.05. Analyses were performed using Comprehensive Meta-analysis (version 3.3, Biostat, Englewood, NJ, USA).

Funding and potential conflicts of interest

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Results

Study selection

After screening 340 records for eligibility, 19 studies were included in this review, including 15 single-center comparative studies with 6,620 patients (2,278 A; 4,342 P) and 4 multicenter registries with 157,687 patients (18,735 A; 138,952 P). Primary reasons for study exclusion included mean follow-up less than 1 year (27 studies), complications not reported (25 studies), and no comparison of A with P (20 studies) (Figure).

Study and patient characteristics

This review included 4 randomized controlled trials, 1 prospective nonrandomized study, 10 retrospective studies, and 4 multicenter registries. Surgeries in each group occurred during the same period in 11 studies. In 7 studies, learning curve cases comprised some or all of the A group. Median follow-up duration was 16 months (range: 12–64 months) with A and 18 months (range: 12–110 months) with P. Comparing patients treated with A versus P, baseline patient characteristics were well matched for age (median 63 years per group), female sex (median 60% versus 58%), and BMI (median 28 per group).
Complications
The A was associated with lower rates of infection (RR = 0.55, p = 0.002 from 7 studies), dislocation (RR = 0.65, p = 0.03 from 11 studies), and reoperation (RR = 0.84, p < 0.001 from 16 studies). In a subgroup analysis of infection, the rate of superficial (RR = 0.47, p = 0.5) and deep infection (RR = 0.23, p = 0.1) remained low with A, but neither was statistically significant. When explicitly reported, the most common reasons for reoperation were aseptic loosening, dislocation, fracture, and infection in the A group and dislocation, aseptic loosening, infection, and fracture in the P group. No statistically significant differences were observed in the rate of thromboembolic event (RR = 0.59, p = 0.5 from 4 studies), heterotopic ossification (RR = 0.63, p = 0.1 from 4 studies), wound complication (RR = 0.93, p = 0.8 from 5 studies), or fracture (RR = 1.0, p = 0.9 from 10 studies). Most fracture reports were of intraoperative periprosthetic fractures; however, type and time to fracture was not consistently reported.

There was a higher rate of patient-reported nerve injury with A vs. P (RR = 2.3, p = 0.01 from 2 studies). Nerve injuries were described as patient-reported sensory deficit (Luo et al. 2016) or patient-reported nerve injury with no distinction between

(Table 1). The primary risks of bias were attributable to inclusion of retrospective nonrandomized studies (Table 2).

Table 1. Study and patient characteristics

| Study                     | Study design | Treatment period | Parallel treatment period | Learning cases included | Mean follow-up, months | Sample size | Mean age, years | Female, % | Mean BMI |
|---------------------------|--------------|------------------|---------------------------|-------------------------|------------------------|-------------|----------------|-----------|---------|
| Comparative studies:      |              |                  |                           |                         |                        |             |                |           |         |
| Balasubramaniam et al. 2016 | RN           | 2006–2011        | No                        | 12                      | 12                     | 50          | 42             | 63        | 57      |
| Barrett et al. 2013       | RCT          | 2010–2011        | Yes                       | 12                      | 12                     | 43          | 44             | 61        | 63      |
| Batailler et al. 2017     | RN           | 2013–2015        | Yes                       | 14                      | 14                     | 201         | 101            | 72        | 74      |
| Fransen et al. 2016       | RN           | 2012             | Yes                       | 12                      | 12                     | 45          | 38             | 64        | 63      |
| Luo et al. 2016           | RCT          | 2014             | Yes                       | 14                      | 14                     | 52          | 52             | 62        | 64      |
| Malek et al. 2016         | RN           | 2010–2014        | Yes                       | 18                      | 18                     | 265         | 183            | 71        | 70      |
| Newman et al. 2016        | RN           | –                | NR                        | 24                      | 24                     | 235         | 120            | 63        | 59      |
| Rathod et al. 2014        | RN           | 2007–2011        | No                        | 16                      | 30                     | 286         | 293            | 62        | 61      |
| Rodriguez et al. 2014     | PN           | 2010             | Yes                       | 12                      | 12                     | 60          | 60             | 60        | 59      |
| Sugano et al. 2009        | RN           | 2005–2007        | No                        | NR                      | 24                      | 24         | 33             | 39        | 56      |
| Taunton et al. 2014       | RCT          | 2012             | Yes                       | 12                      | 12                     | 27          | 27             | 62        | 66      |
| Tripuraneni et al. 2016   | RCT          | 2012–2015        | Yes                       | 14                      | 13                     | 66          | 66             | 60        | 60      |
| Tsukada and Wakui 2015    | RN           | 2000–2009        | No                        | NR                      | 64                      | 110         | 139            | 177       | 67      |
| Watts et al. 2015         | RN           | 2010–2014        | NR                        | NR                      | 12                      | 12         | 716            | 3,040     | 64      |
| Zhang et al. 2006         | RCT          | 2002–2004        | Yes                       | NR                      | 20                      | 20         | 60             | 61        | 63      |
| Registries                |              |                  |                           |                         |                        |             |                |           |         |
| Amlie et al. 2014         | RN           | 2008–2010        | Yes                       | 24                      | 30                     | 421         | 421            | 67        | 66      |
| Mjaaland et al. 2017      | RN           | 2008–2013        | Yes                       | 52                      | 52                     | 2,017       | 5,961          | 67        | 65      |
| Sheth et al. 2015         | RN           | 2001–2011        | No                        | 36                      | 36                     | 1,851       | 31,747         | 65        | 66      |
| Zijlstra et al. 2017      | RN           | 2007–2015        | No                        | NR                      | 40                      | 40         | 14,446         | 100,823   | –       |

A = anterior approach; P = posterior approach; NR = not reported

* Study design: PN = prospective nonrandomized; RCT = randomized controlled trial; RN = retrospective nonrandomized.

b Reported as number of patients or hips.

c All patients with BMI ≤ 27 kg/m².

Table 2. Cochrane risk of bias assessment

| Study                     | A  | B  | C  | D  | E  | F  | G  |
|---------------------------|----|----|----|----|----|----|----|
| Comparative studies:      |    |    |    |    |    |    |    |
| Balasubramaniam et al. 2016 | ● | ● | ● | ● | ● | ● | ● |
| Barrett et al. 2013       | ● | ● | ● | ● | ● | ● | ● |
| Batailler et al. 2017     | ● | ● | ● | ● | ● | ● | ● |
| Fransen et al. 2016       | ● | ● | ● | ● | ● | ● | ● |
| Luo et al. 2016           | ● | ● | ● | ● | ● | ● | ● |
| Malek et al. 2016         | ● | ● | ● | ● | ● | ● | ● |
| Newman et al. 2016        | ● | ● | ● | ● | ● | ● | ● |
| Rathod et al. 2014        | ● | ● | ● | ● | ● | ● | ● |
| Rodriguez et al. 2014     | ● | ● | ● | ● | ● | ● | ● |
| Sugano et al. 2009        | ● | ● | ● | ● | ● | ● | ● |
| Taunton et al. 2014       | ● | ● | ● | ● | ● | ● | ● |
| Tripuraneni et al. 2016   | ● | ● | ● | ● | ● | ● | ● |
| Tsukada and Wakui 2015    | ● | ● | ● | ● | ● | ● | ● |
| Watts et al. 2015         | ● | ● | ● | ● | ● | ● | ● |
| Zhang et al. 2006         | ● | ● | ● | ● | ● | ● | ● |
| Registries                |    |    |    |    |    |    |    |
| Amlie et al. 2014         | ● | ● | ● | ● | ● | ● | ● |
| Mjaaland et al. 2017      | ● | ● | ● | ● | ● | ● | ● |
| Sheth et al. 2015         | ● | ● | ● | ● | ● | ● | ● |
| Zijlstra et al. 2017      | ● | ● | ● | ● | ● | ● | ● |

Notes: ● low bias risk; ○ uncertain bias risk; □ high bias risk.

A. Random sequence generation
B. Allocation concealment
C. Blinding of participants
D. Blinding of personnel
E. Blinding of outcome assessment
F. Incomplete outcome data
G. Selective outcome reporting
sensory and motor involvement (Amlie et al. 2014). For each complication, heterogeneity among studies was low and publication bias was not evident (Table 3).

**Post hoc meta-regression**

Post hoc meta-regression was performed to assess the possible influence of study design, median surgery year, inclusion of learning cases, and follow-up duration on complication risk. No covariate was statistically significantly associated with the risk of any complication. In comparative studies, there was no statistically significant difference between A vs. P in the rate of any complication. In registries, the rate of patient-reported nerve injury was higher with A while the rates of infection and reoperation were lower with A (Table 4).

**Discussion**

We conducted a systematic review and meta-analysis of comparative studies of A versus P primary THA with at least 1-year mean follow-up. An anterior approach was associated with a lower risk of reoperation, dislocation, and infection, but higher risk of patient-reported nerve injury. No difference was seen in the rate of thromboembolic event, heterotopic ossification, wound complication, or fracture. While heterogeneity or publication bias was not evident for any outcome, the possibility of such influences cannot be ruled out given the small number of studies reporting each complication.

A criticism of the A in primary THA is the presence of a learning curve, during which complication rates may be elevated. In an analysis of over 5,000 THA procedures, 50 or more A procedures were required to overcome the learning curve.

### Table 3. Complication rates with anterior versus posterior approach in primary total hip arthroplasty

| Outcome                        | Studies | Event rate per 100 person-years | Effect size | Heterogeneity | Publication bias |
|--------------------------------|---------|---------------------------------|-------------|---------------|-----------------|
|                                |         | A                               | P           | Rate ratio    | I², %           |
| Infection                      | 7       | 0.2                             | 0.4         | 0.55 (0.38–0.80) | 0.002           | 0.5             |
| Thromboembolic event           | 4       | 0.5                             | 1.1         | 0.59 (0.14–2.43) | 0.5             | 0.2             |
| Heterotopic ossification       | 4       | 1.5                             | 2.3         | 0.63 (0.35–1.13) | 0.1             | 0.3             |
| Dislocation                    | 11      | 0.2                             | 0.2         | 0.65 (0.44–0.95) | 0.03            | 17              |
| Reoperation                    | 16      | 0.6                             | 0.7         | 0.84 (0.75–0.93) | < 0.001         | 0.5             |
| Wound                          | 5       | 1.7                             | 1.9         | 0.93 (0.54–1.63) | 0.8             | 0.4             |
| Fracture                       | 10      | 0.3                             | 0.1         | 1.02 (0.75–1.38) | 0.9             | 0.2             |
| Patient-reported nerve injury  | 2       | 3.0                             | 1.3         | 2.31 (1.22–4.39) | 0.01            | 0.5             |

**Notes:** A = anterior approach; P = posterior approach.

*Rate ratio > 1 indicates higher complication incidence rate with anterior approach; rate ratio < 1 indicates lower complication incidence rate with anterior approach.

### Table 4. Subgroup analysis of study design on complication rates with anterior versus posterior approach in primary total hip arthroplasty

| Outcome                        | Comparative studies | Registries |
|--------------------------------|---------------------|-------------|
|                                | Studies             | Rate ratio (95% CI) | Studies | Rate ratio (95% CI) | p-value |
| Infection                      | 6                   | 0.66 (0.16–2.7)    | 1       | 0.55 (0.37–0.80)    | 0.8     |
| Thromboembolic event           | 4                   | 0.59 (0.14–2.4)    | 0       | –                  | –       |
| Heterotopic ossification       | 3                   | 0.58 (0.30–1.2)    | 1       | 0.81 (0.24–2.7)     | 0.6     |
| Dislocation                    | 8                   | 0.55 (0.17–1.8)    | 3       | 0.74 (0.39–1.4)     | 0.7     |
| Reoperation                    | 12                  | 1.03 (0.60–1.8)    | 4       | 0.83 (0.72–0.95)    | 0.5     |
| Wound                          | 5                   | 0.93 (0.54–1.6)    | 0       | –                  | –       |
| Fracture                       | 9                   | 1.7 (0.79–3.7)     | 1       | 0.93 (0.66–1.3)     | 0.2     |
| Patient-reported nerve injury  | 1                   | 5.0 (0.24–104)     | 1       | 2.2 (1.2–4.3)       | 0.6     |

**Notes:**

*Rate ratio > 1 indicates higher complication incidence rate with anterior approach; RR < 1 indicates lower complication incidence rate with anterior approach.

b Comparison of rate ratio in comparative studies versus registries, derived from Knapp–Hartung random effects meta-regression model.
curve (de Steiger et al. 2015). In a single-surgeon experience with the first 500 A cases, the most dramatic reduction in complication rates occurred after the first 100 cases (Hartford and Bellino 2017). We identified no substantial influence of learning case inclusion on complication rates in meta-regression although this analysis was limited since it was not possible to determine the percentage of the entire sample comprising learning cases.

We identified a higher rate of patient-reported nerve injury with A. In the study of Amlie et al. (2014), nerve injury was self-reported in 5.9% of A patients at 24 months follow-up and 3.3% of P patients at 30 months follow-up; however, there was no distinction between sensory or motor involvement. In another comparative study (Luo et al. 2016), sensory deficit was 3.8% with A and 0% with P at 14 months follow-up. While comparative nerve injury data were limited to these 2 studies, a high incidence of sensory deficit with A has been reported in other studies (Bhargava et al. 2010, Goulding et al. 2010). This is primarily attributable to likely iatrogenic injury of the lateral cutaneous femoral nerve. Despite the higher patient-reported nerve injury rate with A, long-term functional limitations or higher reoperation rates are unlikely with these events based on the findings from other studies (Bhargava et al. 2010, Goulding et al. 2010).

In a meta-analysis comparing A and P (Higgins et al. 2015), there were no group differences in risk of intraoperative fracture and lower risk of dislocation with A. More recently, a systematic review compared anterior, posterior, and lateral approaches in primary THA (Meermans et al. 2017). In that review, complications were not systematically evaluated although the authors concluded that there were similar rates of complications between surgical approaches. In a network meta-analysis of randomized controlled trials (Putananon et al. 2018), complication risk was reported to be lower with P vs. A (1.0% vs. 1.4%); however, specific complications were not described. Among these reviews, follow-up duration varied considerably and was generally less than 1 year. Key differences in our meta-analysis are inclusion of only those studies with mean follow-up of at least 1 year, reporting of multiple specific complications, and statistical adjustment to account for differential follow-up periods among studies.

Several aspects of our meta-analysis are novel including the longest duration follow-up of any A versus P review and a comprehensive assessment of complication rates. There are also several limitations. First, despite the longest mean follow-up of any review on this topic, it must be acknowledged that data derived from 16 (A) to 18 (P) months median follow-up must be considered preliminary. Further, while the RR statistic allows for group comparison of event rates on a common scale (per person-year), event rates that are non-constant with respect to time may complicate interpretation of these results. Second, while osteoarthritis was the predominant diagnosis in each study, reporting of THA indications was inconsistent and may have confounded outcomes.

Third, due to the small number of studies reporting certain complications, some complication estimates reported in this review may change with the addition of data by future studies. Further, the influence of study design on complication rates should be interpreted cautiously given the small number of studies for subgroup comparisons. Fourth, complication reporting was generally inconsistent among studies. Adherence to standardized complication reporting guidelines would greatly improve data transparency and consistency in the THA literature. Fifth, no conclusions regarding complication risk with anterolateral or lateral approaches in THA may be derived from this review. Finally, 14 of 19 included studies were retrospective in nature, which are inherently prone to bias.

In summary, comparing A with P in primary THA, A was associated with a lower rate of reoperation, dislocation, and infection, but a higher rate of patient-reported nerve injury.

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