A systematic review—meta-analysis of venous thromboembolic events following primary hip arthroscopy for FAI: clinical and epidemiologic considerations

Ioanna K. Bolia¹, Lorenzo Fagotti¹, Shannen McNamara¹, Grant Dornan¹, Karen K. Briggs¹ and Marc J. Philippon¹,2*

¹Department of Hip Research, Steadman Philippon Research Institute and
²Department of Hip Research, The Steadman Clinic, 181 W. Meadow Dr. 81657 Vail, CO, USA
*Correspondence to: M. J. Philippon. E-mail: drphilippon@sprivail.org

Submitted 31 January 2018; revised version accepted 8 July 2018

ABSTRACT

The purpose of this study was to report the proportion of venous thromboembolic events (VTE) in patients undergoing primary hip arthroscopy for femoroacetabular impingement (FAI) and present a critical overview of the literature to aid in better result interpretation. MedLine, Scopus and Web of Science databases were searched from January 2000 to March 2017. Four thousand-five-hundred and seventy-seven hip cases were included in the meta-analysis of 38 studies. The mean age of patients was 36 ± 1.8 years and the mean follow-up time was 20.6 months. The meta-analysed rate of deep vein thrombosis (DVT) in patients undergoing primary hip arthroscopy for FAI syndrome was 1.18%; 95%CI [0.8–1.74%]; The meta-analysed rate of pulmonary embolism (PE) in patients undergoing primary hip arthroscopy for FAI syndrome was 0.59%; 95%CI [0.38–0.92%]. Quality assessment was performed using the Methodological Index for Non-Randomized Studies (MINORS) criteria the Quality in Prognostic Studies (QUIPS) tool. Sensitivity analysis was conducted to assess for publication bias and its influence on the results. The corrected for publication bias proportion of DVT was 2.02%; 95%CI [1.36–2.99%]. The DVT rate was double following the correction of bias while additional types of bias were detected. Attention must be paid when considering the outcomes of observational studies to make clinical decisions. Insufficient evidence exists to support whether anti-VTE chemoprophylaxis should be administered to patients undergoing primary hip arthroscopy for FAI. Due to the life-threatening character of this complication, the results should serve as starting point to design clinical trials and establish guidelines. Until then, the application of preventive measures against VTE should be decided on a case-by-case basis.

INTRODUCTION

Hip arthroscopy has advanced over the years, and its indications have expanded. The number of post-operative complications has increased accordingly [1, 2]. Commonly reported complications following hip arthroscopy include nerve injury, iatrogenic chondrolabral injury, skin damage, infection, avascular necrosis of the femoral head, hip dislocation, femoral neck fracture, heterotopic ossification, intra-abdominal or intra-thoracic fluid extravasation and venous thromboembolic events (VTE) including deep vein thrombosis (DVT) and pulmonary embolism (PE) [3, 4]. A blood clot, which is commonly formed in the deep venous system of the lower limb, may subsequently get wedged into the pulmonary artery or its branches and lead to compromise of the pulmonary blood supply which sometimes leads to patient’s death.

Orthopaedic surgical procedures may carry increased risk for the development of VTE due to temporary endothelial dysfunction at the operation site, venous stasis as a result of patient immobilization during the recovery period and...
possible hypercoagulability state which is also patient dependent [5]. According to the American College of Chest Physicians (ACCP), there is no validated tool to assess individual risk factors and their contribution to the development of VTE in patients undergoing orthopaedic procedures [6]. These factors may include previous VTE, cardiovascular disease, Charlson comorbidity index $\geq 3$, body mass index (BMI) $>25$ kg/m$^2$, age (OR, 1.1 for each 5-year increment versus age $<40$ years), advanced age $\geq 85$ years, varicose veins and ambulation before day 2 after surgery [6]. Apart from patient factors, it is unknown if hip arthroscopy carries increased risk for the development of VTE compared to knee arthroscopy where routine anti-VTE chemoprophylaxis is not recommended. An arthroscopic hip procedure includes foot and ankle immobility, use of traction, surgical manoeuvres performed in proximity to the deep femoral vein system where thrombi can form and usually spinal or epidural anaesthesia which causes venodilation and blood stasis [7, 8].

**MATERIALS AND METHODS**

This study was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

**Search strategy**

Three reviewers (IKB, LF, SM) searched three online databases (MedLine, Scopus and Web of Science) for relevant articles. Search strings were applied to all databases including: timeline constraints from 2000 to 2017; case-control study; cohort study; comparative studies; observational study; journal article; article in English language. The following keywords were used in all three databases: DVT hip arthroscopy; PE hip arthroscopy; venous thromboembolism hip arthroscopy; complications hip arthroscopy; DVT femoroacetabular impingement (FAI); PE FAI; venous thromboembolism FAI. Hand searching was conducted by 1 reviewer to retrieve additional pertinent articles.

**Inclusion and exclusion criteria**

The inclusion criteria were (1) non-randomized prospective and retrospective observational studies reporting whether any complication was observed during the follow-up period and/or the rate of complications and/or the proportion of VTE following hip arthroscopy, (2) articles in English with full text availability, (3) articles published in peer reviewed journals from January 2000 to March 2017, (4) studies where the patients who had previous hip surgery were excluded or it was possible to exclude them manually after reviewing the article, (5) studies where the indication for hip arthroscopy was reported. The exclusion criteria were (1) studies where the rate of DVT/PE following hip arthroscopy was not reported, (2) studies where the complications following hip arthroscopy were not reported, (3) non-English articles, (4) different studies that were conducted on the same patient population (the study with the largest patient population was included), (5) studies where the indication for hip arthroscopy was other than FAI, (6) studies on patients younger than 18 years of age, (7) studies conducted using national or international databases. Two reviewers applied the study criteria and a third reviewer was consulted in cases of disagreement.

**Search results**

Four hundred fifty-two studies were retrieved from the electronic search of the three databases. The title and abstract screening of 131 articles yielded 101 articles that were eligible for full text screening. We finally included 73 studies; 38 in the quantitative synthesis (meta-analysis)
and 35 in the qualitative synthesis of this systematic review (Fig. 1).

**Study quality assessment**

For the articles included in the meta-analysis quality assessment was performed using the Methodological Index for Non-Randomized Studies (MINORS) criteria and the risk of bias assessment was conducted using the Quality in Prognostic Studies (QUIPS) tool (Cochrane methods). Both evaluation tools were applied by two reviewers and a third reviewer was consulted in cases of disagreement. The inter-reviewer agreement at all stages of study screening (title, abstract, full text) was assessed by calculating the $k$ value. Confounding (27 studies, 67.5%) and attrition bias (10 studies, 25%) were the two most commonly observed types of bias in the meta-analysed articles, Table II). Prognostic factor measurement was partially reported in 18 studies (18/40, 45%). Most studies had satisfactory outcome measurement methods, statistical analysis and reporting rates. The mean MINORS score was $13.4 \pm 2.8$ points (range: 9–20) indicating a fair quality of evidence. At all three stages of article screening the $k$ value was
higher than 0.60 which indicates substantial agreement between the reviewers’ evaluation.

Data collection and abstraction
Spreadsheets were used for data extraction by the primary author. A second author (SM) evaluated and verified the data accuracy. In cases of disagreement a third reviewer was consulted. Patient demographics (age, gender), pre-operative diagnosis, history of hip disease or previous surgery, any risk factors reported to predispose to VTE, the anti-thrombotic prophylaxis measures, the type of anaesthesia used during the operation and the number and type of VTE complications were recorded for each study.

Meta-analysis and investigation for publication bias
Hip case inclusion-exclusion criteria were applied in each meta-analysed article to improve the homogeneity of the study population. Hip arthroscopy cases were included if no previous procedures had been performed on the same hip and if the indication for hip arthroscopy was FAI. Hip cases were excluded if there was history of previous surgery, avascular necrosis of the femoral head (AVN), pigmented villonodular synovitis, acute traumatic labral tears or cartilage defects, slipped capital femoral epiphysis (SCFE), Legg-Calve-Perthes Disease (LCPD) and if the hip arthroscopic procedure was performed in combination with endoscopic (gluteus medius pathology, trochanteric bursitis, sciatic nerve decompression) or open hip surgery. In addition, high risk patients who developed VTE complication following hip arthroscopy were not included in the meta-analysis.

To allow for generalizability of the results beyond the set of included studies, random-effects meta-analysis was used. Residual heterogeneity was estimated using the DerSimonian-Laird method, reported using the I2 statistic and presented with 95% confidence intervals. Evidence for publication bias was assessed using funnel plots and symmetry was tested using the rank correlation test. The statistical software R version 3.3.2 was used to produce all analyses and results figures (R, R Foundation for Statistical Computing with additional packages meta and metafor).

RESULTS
Four thousand five hundred and seventy-seven hip cases were included in the meta-analysis of 38 studies. The mean age of patients was 36 ± 1.8 years and the mean follow-up time was 20.6 months. The meta-analysed rate of DVT in low risk patients undergoing primary hip arthroscopy for FAI was 1.18%; 95%CI [0.8–1.74%]; The meta-analysed rate of PE in low risk patients undergoing primary hip arthroscopy for FAI was 0.59%; 95%CI [0.38–0.92%].

Epidemiologic analysis
Most included articles were of level of evidence IV (27/38, 71%). Five studies (13%) were of level of evidence III and 6 studies (16%) were of level II of evidence. Whether or not anti-VTE prophylaxis was used in patients undergoing primary hip arthroscopy for FAI and the type of measures taken to avoid this complication were significantly underdocumented. Most articles (23/38, 60.5%) did not report whether anti-VTE was used. Five studies (13.1%) did not recommend any type of anti-VTE prophylaxis, while mechanical prophylaxis (compression device) and chemoprophylaxis were recommended in five studies (13.1%) and five studies (13.1%), respectively (Table I).

Table II presents the different types and distribution of bias among the meta-analysed studies as identified using the QUIPS tool. Confounding (23/38, 60.5%) and attrition bias (25/38, 65.7%) were most commonly observed.

Regarding the estimation of the DVT rate, the study heterogeneity (I2) was 29.3%; 95%CI [0–52%]. Rank test for funnel plot asymmetry (Fig. 2) was significant (Kendall’s tau = 0.4499, P < 0.001), thus we had evidence for possible publication bias. The last means that small studies with low DVT rates were more likely to be published than larger studies with low DVT rates. The corrected for publication bias proportion of DVT was 2.02%; 95% CI [1.36–2.99%], which shows that publication bias significantly affected the result.

The rank test for funnel plot asymmetry was not significant (Kendall’s tau = 0.9364, P > 0.001) when investigating the PE rate, thus no publication bias was observed in this case. The study heterogeneity I2 was 0%. In conclusion, no sufficient data are available to guide the clinical practice on the use of routine chemoprophylaxis against VTE in low-risk patients undergoing primary hip arthroscopy for FAI.

DISCUSSION
Limitations
The main limitation of this study is that most of meta-analysed studies are of level IV of evidence. Furthermore, significant amount of confounding and attrition bias was detected which raises concerns regarding the validity of the results. On the other hand, the only available source of data for the calculation of the VTE rate following primary hip arthroscopy for FAI syndrome were follow-up studies. All the included studies have sufficient follow-up time to assess for the development of VTE after orthopaedic procedures as recommended by ACCP [6]. Sensitivity analysis was conducted to assess for possible publication bias which basically resulted from the analysis of retrospective and
| Study            | # patients (# hip cases meta-analysed) | DVT rate (95%CI)    | PE rate (95%CI)  | Comments                                      | Anti-thrombotic prophylaxis | Anaesthesia |
|------------------|---------------------------------------|---------------------|------------------|-----------------------------------------------|----------------------------|-------------|
| Mohtadi et al.   | 120 (115)                             | 4.35% (1.43–9.85)   | 0% (0–3.16%)     | Doppler U/S screening 4/5 patients were symptomatic | Early mobilization         | N/R         |
| Fukushima et al. | 72 (72)                               | 6.94% (2.29–15.47)  | 0% (0–4.99)      | Doppler U/S screening Asymptomatic patients   | No anticoagulants         | General     |
| Gupta et al.     | 587 (587)                             | 0.68% (0.19–1.74)   | 0.17% (0–0.95)   | Clinical outcome study                        | N/R                       | N/R         |
| Salvo et al.     | 81 (76)                               | 2.63% (0.32–9.18)   | 0% (0–4.74)      | N/A                                           | No chemical or mechanical prophylaxis | N/R         |
| Chan et al.      | 211 (236)                             | 0.85% (0.1–3.03)    | 0% (0–1.55)      | N/A                                           | No prophylaxis            | N/R         |
| Collins et al.   | 39 (39)                               | 5.13% (0.63–17.32)  | 0% (0–9.03)      | DVT occurred in obese patients (BMI ≥ 25)     | acetylsaliclyc acid 325 mg daily for 2 weeks | General     |
| Alaia et al.     | 139 (139)                             | 0.72% (0.02–3.94)   | 0.072% (0.02–3.94) | N/A                                           | No prophylaxis            | General     |
| Souza et al.     | 194 (194)                             | 0.52% (0.01–2.84)   | 0% (0–1.88)      | N/A                                           | Early mobilization        | General     |
| Awan et al.      | 22 (14)                               | 0% (0–23.16)        | 0% (0–23.16)     | Clinical outcome study                        | N/R                       | N/R         |
| Byrd et al. [9]  | 50 (47)                               | 0% (0–7.55)         | 0% (0–7.55)      | Clinical outcome study                        | N/R                       | N/R         |
| Byrd et al. [23] | 200 (207)                             | 0% (0.1.77)         | 0% (0–1.77)      | Clinical outcome study                        | N/R                       | N/R         |
| Byrd et al. [24] | 100 (80)                              | 0% (0–4.51)         | 0% (0–4.51)      | Clinical outcome study                        | N/R                       | N/R         |
| Byrd et al. [25] | 116 (115)                             | 0% (0–3.16)         | 0% (0–3.16)      | Clinical outcome study                        | N/R                       | N/R         |
| Byrd et al. [26] | 37 (38)                               | 0% (0–9.25)         | 0% (0–9.25)      | Clinical outcome study                        | N/R                       | N/R         |
| Byrd et al. [27] | 41 (44)                               | 0% (0–8.04)         | 0% (0–8.04)      | Clinical outcome study                        | N/R                       | N/R         |
| Contreras et al. | 147 (150)                             | 0% (0–2.43)         | 0% (0–2.43)      | N/A                                           | N/R                       | General     |
| Study                     | # patients (# hip cases meta-analysed) | DVT rate (95%CI) | PE rate (95%CI) | Comments                      | Anti-thrombotic prophylaxis | Anaesthesia  |
|--------------------------|----------------------------------------|------------------|-----------------|-------------------------------|----------------------------|--------------|
| Dietrich et al. [10]     | 317 (317)                              | 0% (0–1.16)      | 0% (0–1.16)     | N/A                           | N/R                        | N/R          |
| Domb et al. [29]         | 22 (21)                                | 0% (0–16.1)      | 0% (0–16.1)     | Clinical outcome study        | N/R                        | N/R          |
| Dutton et al. [11]       | 159 (159)                              | 0% (0–2.29)      | 0% (0–2.29)     | N/A                           | N/R                        | N/R          |
| Flecher et al. [30]      | 23 (23)                                | 0% (0–14.82)     | 0% (0–14.82)    | N/A                           | N/R                        | N/R          |
| Fukui et al. [31]        | 100 (82)                               | 0% (0–4.40)      | 0% (0–4.40)     | Clinical outcome study        | N/R                        | N/R          |
| Hartigan et al. [32]     | 78 (82)                                | 0% (0–4.40)      | 0% (0–4.40)     | Clinical outcome study        | No DVT prophylaxis         | N/R          |
| Haviv et al. [33]        | 82 (164)                               | 0% (0–2.22)      | 0% (0–2.22)     | Clinical outcome study        | N/R                        | General      |
| Horisberger et al. [34]  | 20 (20)                                | 0% (0–16.84)     | 0% (0–16.84)    | Clinical outcome study        | At least 2 weeks of LMWH   | N/R          |
| Javed et al. [35]        | 40 (40)                                | 0% (0–8.81)      | 0% (0–8.81)     | Clinical outcome study        | N/R                        | N/R          |
| Kamath et al. [36]       | 52 (31)                                | 0% (0–11.22)     | 0% (0–11.22)    | Clinical outcome study        | N/R                        | N/R          |
| Krych et al. [37]        | 30 (30)                                | 0% (0–11.57)     | 0% (0–11.57)    | Clinical outcome study        | N/R                        | N/R          |
| Larson et al. [38]       | 90 (94)                                | 0% (0–3.85)      | 0% (0–3.85)     | N/A                           | ASA 650/daily and/or compres- | N/R          |
|                          |                                        |                  |                 |                               | sion stockings, early mobilization |              |
| Lo et al. [39]           | 72 (73)                                | 0% (0–5.06)      | 0% (0–5.06)     | N/A                           | N/R                        | General      |
| Matsuda et al. [40]      | 140 (147)                              | 0% (0–2.48)      | 0% (0–2.48)     | Clinical outcome study        | N/R                        | General      |
| Mei Dan et al. [41]      | 122 (121)                              | 0% (0–3.00)      | 0% (0–3.00)     | Clinical outcome study        | N/R                        | General      |
| Nossa et al. [42]        | 360 (362)                              | 0% (0–1.01)      | 0% (0–1.01)     | N/A                           | Anti-thrombotic prophylaxis | N/R          |

(continued)
prospective follow-up studies. Although trim and fill method is a reliable tool to address publication bias, we cannot assume that the last was eliminated. Another limitation of this study is the selection of hip cases that were analysed. We focused on patients that had no previous surgery and no history or pre-operative diagnosis of pigmented villonodular synovitis, avascular necrosis of the femoral head, acute traumatic FAI, SCFE and LCPD. We excluded studies that did not provide any information about the patient history of disease or previous hip procedures, but this does not completely eradicate the risk of including cases that were not eligible. Thus, the homogeneity of the study population may be questionable. The highest proportion of VTE after hip arthroscopy was detected in two prospective studies where ultrasound was used to screen both symptomatic and asymptomatic patients at pre-determined time points after the procedure. Fukushima et al. [12] reported 6.94% incidence of DVT in a cohort of 72 patients. Mohtadi et al. [13] also used Doppler ultrasound to screen patients for DVT on days 10–22 after hip arthroscopy and reported an incidence of 4.3% (4 cases). Ultrasound screening for the development VTE after orthopaedic procedures is not currently recommended in asymptomatic individuals. On the other hand, asymptomatic cases might have remained undetected and were not included in this analysis, leading to possible underestimation of the proportion of VTE.

**Background and rationale**

The systematic review found the rate of DVT and PE in patients undergoing primary hip arthroscopy for FAI to be 1.18% and 0.59%, respectively. Publication bias was evident when calculating the DVT rate which was raised to 2.02% after the bias was corrected. In addition, significant amount of confounding and attrition bias was detected among the studies. Thus, current evidence is insufficient to introduce specific recommendations regarding the administration of routine anti-VTE chemoprophylaxis in low-risk patients undergoing primary hip arthroscopy for FAI.

Recently, Haldane et al. [14] compared the post-hip arthroscopy VTE rate (PE and DVT events) in patients who underwent hip arthroscopy for FAI and were administered VTE chemoprophylaxis versus those who did not. The VTE rate was 2% in patients where VTE prophylaxis was used and 2.3% in the group of patients who did not take VTE chemoprophylaxis. Due to key differences in

| Study | # patients (# hip cases meta-analysed) | DVT rate (95%CI) | PE rate (95%CI) | Comments | Anti-thrombotic prophylaxis | Anaesthesia |
|-------|--------------------------------------|-----------------|----------------|----------|-----------------------------|-------------|
| Palihe et al. [43] | 150 (96) | 0% (0–3.77) | 0% (0–3.77) | N/A | N/R | General |
| Park et al. [44] | 200 (200) | 0% (0–1.83) | 0% (0–1.83) | N/A | Early mobilization | General |
| Polat et al. [45] | 42 (42) | 0% (0–8.41) | 0% (0–8.41) | Clinical outcome study | Anti-thrombotic prophylaxis | N/R |
| Roos et al. [46] | 40 (41) | 2.44 (0.06–12.8) | 3 | Clinical Outcome study | Full weight bearing allowed | N/R |
| Seijas et al. [1] | 258 (258) | 0% (0–1.42) | 0% (0–1.42) | N/A | Enoxaparin 40 Iu/24 h for 10 days | Combined intra- and epidural |
| Zingg et al. [47] | 23 (23) | 0% (0–14.82) | 0% (0–14.82) | Clinical outcome study | N/R | General |
| **Total** | **Hip cases:** 4577 | **DVT 1.18%; 95%CI [0.8–1.74]** | **PE 0.59%; 95%CI 0.38–0.92.** | | | |
Table II. Types and distribution of bias among the studies

| Author                  | Participation | Attrition | Prognostic factor | Outcome | Confounding | Statistics reporting |
|-------------------------|---------------|-----------|-------------------|---------|-------------|----------------------|
| Alaia et al. [21]       |               |           |                   |         |             |                      |
| Awan et al. [22]        |               |           |                   |         |             |                      |
| Byrd et al. [23]        |               |           |                   |         |             |                      |
| Byrd et al. [9]         |               |           |                   |         |             |                      |
| Byrd et al. [25]        |               |           |                   |         |             |                      |
| Byrd et al. [24]        |               |           |                   |         |             |                      |
| Byrd et al. [27]        |               |           |                   |         |             |                      |
| Byrd et al. [26]        |               |           |                   |         |             |                      |
| Chan et al. [19]        |               |           |                   |         |             |                      |
| Collins et al. [20]     |               |           |                   |         |             |                      |
| Contreras et al. [28]   |               |           |                   |         |             |                      |
| Dietrich et al. [10]    |               |           |                   |         |             |                      |
| Dutton et al. [11]      |               |           |                   |         |             |                      |
| Domb et al. [29]        |               |           |                   |         |             |                      |
| Flecher et al. [30]     |               |           |                   |         |             |                      |
| Fukui et al. [31]       |               |           |                   |         |             |                      |
| Fukushima et al. [12]   |               |           |                   |         |             |                      |
| Gupta et al. [16]       |               |           |                   |         |             |                      |
| Hartigan et al. [32]    |               |           |                   |         |             |                      |
| Haviv et al. [33]       |               |           |                   |         |             |                      |
| Horisberger et al. [34] |               |           |                   |         |             |                      |
| Javed et al. [35]       |               |           |                   |         |             |                      |
| Kamath et al. [36]      |               |           |                   |         |             |                      |
| Krych et al. [37]       |               |           |                   |         |             |                      |
| Larson et al. [38]      |               |           |                   |         |             |                      |
| Lo et al. [39]          |               |           |                   |         |             |                      |
| Mei Dan et al. [41]     |               |           |                   |         |             |                      |
| Matsuda et al. [40]     |               |           |                   |         |             |                      |
| Mohtadi et al. [13]     |               |           |                   |         |             |                      |
| Nossa et al. [42]       |               |           |                   |         |             |                      |
| Pailhe et al. [43]      |               |           |                   |         |             |                      |

(continued)
study design and extraction of the results, comparisons with our systematic review are difficult to make. Our patient population included low risk patients who underwent primary hip arthroscopy for FAI but the selection process to identify the hip cases eligible for analysis was conducted in two stages; first, we applied the study selection criteria to identify eligible articles. At a second stage, we applied inclusion and exclusion criteria to the hip cases included in the study population of each of the selected studies. The last was to ensure that selected patients did not have known risk factors to develop VTE following hip arthroscopy and underwent primary hip arthroscopy for FAI without additional procedures (see Meta-analysis section). We excluded articles where the indications for hip arthroscopy were not clearly stated because this could increase the probability of population heterogeneity. For example, in a study by Clarke et al. [15], which was included in the systematic review of Haldane et al. [14], the study population included patients who underwent hip arthroscopy for undiagnosed hip pain (41%) and other miscellaneous conditions (13%). The last could serve as significant confounder. In addition, we reported the DVT and PE rates separately whereas Haldane et al. [14] reported an overall VTE rate of approximately 2% which included 22 DVT events and 3 PE events. We identified 23 cases of DVT and 2 cases of PE in patients who suffered VTE after

| Author               | Participation | Attrition | Prognostic factor | Outcome | Confounding | Statistics reporting |
|----------------------|---------------|-----------|-------------------|---------|-------------|----------------------|
| Park et al. [44]     |               |           |                   |         |             |                      |
| Polat et al. [45]    |               |           |                   |         |             |                      |
| Roos et al. [46]     |               |           |                   |         |             |                      |
| Salvo et al. [18]    |               |           |                   |         |             |                      |
| Seijas et al. [1]    |               |           |                   |         |             |                      |
| Souza et al. [2]     |               |           |                   |         |             |                      |
| Zingg et al. [47]    |               |           |                   |         |             |                      |

Fig. 2. Funnel plots indicating meta-analysed estimate for DVT rate (A) using a random-effects model for the included studies, and (B) utilizing the trim-and-fill method as a sensitivity analysis. Black dots represent actual studies included in this systematic review, and asymmetry of these dots indicate possible publication bias. White dots represent hypothetical study observations created and used by the trim-and-fill method.
surgery. If any patient was at higher risk for VTE based on the medical history and/or underwent concomitant procedures to address pathology other than FAI, he or she was excluded from our analysis. Similar to our study, the authors included symptomatic and asymptomatic cases of VTE. Kowalczuk et al. [4] reported an overall complication rate of 4% in patients undergoing hip arthroscopy with 0.3% of those being major complications including DVT. DVT was reported as the second most common (4/20, 0.2%) after intra-abdominal fluid extravasation. Harris et al. [3] reported a major complication rate of 0.58% in a meta-analysis of 6334 hip arthroscopy cases including seven cases of DVT (0.1%). The proportion of VTE was underestimated in both studies [3, 4]. The last could be explained by the fact the numerous other complications were reported concomitantly [3, 4].

Mohtadi et al. [13] detected one case of asymptomatic DVT by ultrasound screening of a group of low-risk patients who underwent hip arthroscopy in a prospective study. Fukushima et al. [12] detected five asymptomatic cases of DVT (confirmed by ultrasound) in a group of 72 patients who underwent hip arthroscopy for FAI syndrome. Although routine ultrasound for DVT is not recommended for asymptomatic patients following orthopaedic procedures, these findings raise concerns in whether hip arthroscopy, as a procedure itself, carries increased risk of development of DVT relative to knee arthroscopy where no VTE chemoprophylaxis is recommended by the ACCP in low-risk individuals [6]. Because hip arthroscopy is relatively new procedure and the above findings may be of important clinical significance, the asymptomatic cases of DVT/PE were included in our analysis.

The proportion of DVT patients undergoing primary hip arthroscopy for FAI syndrome was 0.59% in this study. We identified only two cases of DVT in a study population of 4577 patients. The first case of PE was a 30-year old female without pre-existing risk factors for VTE who received general anaesthesia and traction was applied for 50 min during surgery. The patient did not receive chemoprophylaxis for VTE after surgery and she was on toe-touch weight bearing restriction. She developed tachypnea 12 days postoperatively. Imaging studies revealed acute pulmonary emboli in the segmental branches of left upper and lower lungs. Lower extremity ultrasound was negative for DVT. This shows that symptomatic DVT does not necessarily precede the occurrence of PE and the patient can present solely with pulmonary symptoms. The other case of PE was an obese patient with BMI between 35 and 39 who also developed acute DVT in different study [16]. Whether this last patient received chemoprophylaxis against VTE was not reported. In addition, it is unclear if obesity serves as an independent risk factor for the development of VTE after surgery. [17] As mentioned in the previous paragraph, Mohtadi et al. [13] as well as Fukushima et al. [12] detected six cases of asymptomatic DVT by ultrasound screening of a group of low-risk patients who underwent hip arthroscopy. Both studies were prospective. These asymptomatic events of DVT could have potentially resulted in PE and patient death. Based on that, whether routine chemoprophylaxis against VTE should be administered in patients undergoing hip arthroscopy for FAI is a subject that surgeons must take into serious consideration. Harris et al. [3] detected two cases of PE and Haldane et al. [14] detected three cases of PE in their study.

Implication in clinical practice

Previous systematic reviews characterize the incidence of VTE after hip arthroscopy, with the highest reported percentage being 2.3%, as low. [3, 4, 14] We calculated the DVT rate following primary hip arthroscopy for FAI in low risk patients as 1.18% (which was raised to 2.2% after the correction of publication bias) and the PE rate as 0.59%. The study population in the above cohorts, including ours, consists of young patients (mean age less than 45 years) who underwent an elective procedure. Given the life-threatening character of VTE complication an incidence rate of 1–2% cannot be neglected in clinical practice. No data exists to support that DVT chemoprophylaxis should be administered in low-risk patients who undergo hip arthroscopy for FAI, however; the existing evidence is of low quality and this might result in underestimation of a serious clinical problem. The last was clearly stated in the systematic review of Haldane et al. [14] a finding that our study confirms.

Implication in research

There is need to design higher quality studies that will lead to the establishment of evidence-based guidelines for the administration of VTE chemoprophylaxis in low risk patients who undergo hip arthroscopy for FAI; follow-up studies should consistently report the rate and type of post-operative complications observed, including VTE events. Also, whether anti-VTE measures were taken following the procedure as well as the type of these preventive measures should be reported. Clinical trials will help decide if routine VTE prophylaxis should be implemented in clinical practice, and the efficacy of various VTE prophylactic measures should be assessed.
CONCLUSION
Insufficient evidence exists to support whether anti-VTE chemoprophylaxis should be administered to patients undergoing primary hip arthroscopy for FAI. Level IV studies composed most of meta-analysed articles and publication bias significantly affected the results. Due to the life-threatening character of this complication, these results should serve as starting point to design clinical trials and establish guidelines. Until then, the application of prevention measures against VTE should be decided on a case-by-case basis to ensure patient safety.

CONFLICT OF INTEREST STATEMENT
None declared.

REFERENCES
1. Seijas R, Ares O, Sallent A et al. Hip arthroscopy complications regarding surgery and early postoperative care: retrospective study and review of literature. *Musculoskelet Surg* 2017; 101: 119–31.
2. Souza BG, Dani WS, Honda EK et al. Do complications in hip arthroscopy change with experience? *Arthroscopy* 2010; 26: 1053–7.
3. Harris JD, McCormick FM, Abrams GD et al. Complications and reoperations during and after hip arthroscopy: a systematic review of 92 studies and more than 6, 000 patients. *Arthroscopy* 2013; 29: 589–95.
4. Kovalczuk M, Bhandari M, Farrokhyar F et al. Complications following hip arthroscopy: a systematic review and meta-analysis. *Knee Surg Sports Traumatol Arthrosc* 2013; 21: 1669–75.
5. Whiting PS, White-Dzuro GA, Greenberg SE et al. Risk factors for deep venous thrombosis following orthopaedic trauma surgery: an analysis of 56,000 patients. *Arch Trauma Res* 2016; 5: e32915.
6. Falt-Ytter Y, Francis CW, Johanson NA et al. Prevention of VTE in orthopedic surgery patients: antithrombotic therapy and prevention of thrombosis, 9th ed: American College of Chest Physicians evidence-based clinical practice guidelines. Chest 2012; 141: e278S–32S.
7. Nakano N, Khanduja V. Complications in hip arthroscopy. *Muscles Ligaments Tendons J* 2016; 6: 402–9.
8. Nakamura M, Kamei M, Bito S et al. Spinal anesthesia increases the risk of venous thromboembolism in total arthroplasty: secondary analysis of a J-PSVT cohort study on anesthesia. *Medicine* 2017; 96: e6748.
9. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 10-year followup. *Clin Orthop Relat Res* 2010; 468: 741–6.
10. Dietrich F, Ries C, Eiermann C et al. Complications in hip arthroscopy: necessity of supervision during the learning curve. *Knee Surg Sports Traumatol Arthrosc* 2014; 22: 953–8.
11. Dutton JR, Kusnezov NA, Lanzi JT et al. The success of hip arthroscopy in an active duty population. *Arthroscopy* 2016; 32: 2251–8.
12. Fukushima K, Takahira N, Uchiyama K et al. The incidence of deep vein thrombosis (DVT) during hip arthroscopic surgery. *Arch Traum Orthop Surg* 2016; 136: 1431–5.
13. Mohhtdi NG, Johnston K, Gaudelli C et al. The incidence of proximal deep vein thrombosis after elective hip arthroscopy: a prospective cohort study in low risk patients. *J Hip Presv Surg* 2016; 3:295–303.
14. Haldane CE, Ekhtiari S, de Sa D et al. Venous thromboembolism events after hip arthroscopy: a systematic review. *Arthroscopy* 2018; 34: 321–30.e1.
15. Clarke MT, Arora A, Villar RN. Hip arthroscopy: complications in 1054 cases. *Clin Orthop Relat Res* 2003; 406: 84–8.
16. Gupta A, Redmond JM, Hammarstedt JE et al. Does obesity affect outcomes in hip arthroscopy? A matched-pair controlled study with minimum 2-year follow-up. *Am J Sports Med* 2015; 43: 965–71.
17. Yang G, De Staecke C, Hooper WC. The effects of obesity on venous thromboembolism: a review. *Open J Prev Med* 2012; 2: 499–509.
18. Salvo JP, Troxell CB, Duggan DP. Incidence of venous thromboembolic disease following hip arthroscopy. *Orthopedics* 2010; 33: 664.
19. Chan K, Farrokhyar F, Burrow S et al. R. Complications following hip arthroscopy: a retrospective review of the McMaster experience (2009–2012). *Can J Surg* 2013; 56: 422–6.
20. Collins JA, Beutel BG, Garofolo G, Youm T. Correlation of obesity with patient-reported outcomes and complications after hip arthroscopy. *Arthroscopy* 2015; 31: 57–62.
21. Alaia MJ, Patel D, Levy A et al. The incidence of venous thromboembolism (VTE)-after hip arthroscopy. *Bull Hosp Joint Dis* 2014; 72: 154–8.
22. Awan N, Murray P. Role of hip arthroscopy in the diagnosis and treatment of hip joint pathology. *Arthroscopy* 2006; 22: 215–8.
23. Byrd JW, Jones KS. Arthroscopic femoroplasty in the management of cam-type femoroacetabular impingement. *Clin Orthop Relat Res* 2009; 467: 739–46.
24. Byrd JW, Jones KS. Arthroscopic management of femoroacetabular impingement: minimum 2-year follow-up. *Arthroscopy* 2011; 27: 1379–88.
25. Byrd JW, Jones KS. Arthroscopic management of femoroacetabular impingement in athletes. *Am J Sports Med* 2011; 39(Suppl.): 78.
26. ByrdJWT, Jones KS. Primary repair of the acetabular labrum: outcomes with 2 years’ follow-up. *Arthroscopy* 2014; 30: 588–92.
27. Byrd JW, Jones KS. Hip arthroscopy in high-level baseball players. *Arthroscopy* 2015; 31: 1507–10.
28. Contreras ME, Hoffmann RB, de Araujo LC et al. Complications in hip arthroscopy. *Rev Bras Ortop* 2010; 45: 61–6.
29. Domb BG, Stake CE, Lindner D et al. Arthroscopic capsular plication and labral preservation in borderline hip dysplasia: two-year clinical outcomes of a surgical approach to a challenging problem. *Am J Sports Med* 2013; 41: 2591–8.
30. Flecher X, Dumas J, Argenson JN. Is a hip distractor useful in the arthroscopic treatment of femoroacetabular impingement? *Orthop Traumatol Surg Res* 2011; 97: 381–8.

31. Fukui K, Briggs KK, Trindade CA et al. Outcomes after labral repair in patients with femoroacetabular impingement and borderline dysplasia. *Arthroscopy* 2015; 31: 2371–9.

32. Hartigan DE, Perets I, Walsh JP et al. Clinical outcomes of hip arthroscopy in radiographically diagnosed retroverted acetabula. *Am J Sports Med* 2016; 44: 2531–6.

33. Haviv B, O’Donnell J. Arthroscopic treatment for symptomatic bilateral cam-type femoroacetabular impingement. *Orthopedics* 2010; 33: 874.

34. Horisberger M, Brunner A, Herzog RF. Arthroscopic treatment of femoral acetabular impingement in patients with preoperative generalized degenerative changes. *Arthroscopy* 2010; 26: 623–9.

35. Javed A, O’Donnell JM. Arthroscopic femoral osteochondroplasty for cam femoroacetabular impingement in patients over 60 years of age. *J Bone Joint Surg Br* 2011; 93-B: 326–31.

36. Kamath AF, Componovo R, Baldwin K et al. Hip arthroscopy for labral tears: review of clinical outcomes with 4.8-year mean follow-up. *Am J Sports Med* 2009; 37: 1721–7.

37. Krych AJ, Baran S, Kuzma SA et al. Utility of multimodal analgesia with fascia iliaca blockade for acute pain management following hip arthroscopy. *Knee Surg Sports Traumatol Arthrosc* 2014; 22: 843–7.

38. Larson CM, Giveans MR, Stone RM. Arthroscopic debridement versus refixation of the acetabular labrum associated with femoroacetabular impingement: mean 3.5-year follow-up. *Am J Sports Surg* 2012; 40: 1015–21.

39. Lo YP, Chan YS, Lien LC et al. Complications of hip arthroscopy: analysis of seventy three cases. *Chang Gung Med J* 2006; 29: 86–92.

40. Matsuda DK, Gupta N, Burchette RJ et al. Arthroscopic surgery for global versus focal pincer femoroacetabular impingement: are the outcomes different? *J Hip Preserv Surg* 2015; 2: 42–50.

41. Mei-Dan O, Conkey MO, Knudsen JS et al. Bilateral hip arthroscopy under the same anesthetic for patients with symptomatic bilateral femoroacetabular impingement: 1-year outcomes. *Arthroscopy* 30(1): 47–54.

42. Nossa JM, Aguilera B, Márquez W et al. Factors associated with hip arthroscopy complications in the treatment of femoroacetabular impingement. *Curr Orthop Pract* 2014; 25: 362–6.

43. Pailhe R, Chiron P, Reina N et al. Pudendal nerve neuralgia after hip arthroscopy: retrospective study and literature review. *Knee Surg Sports Traumatol Arthrosc* 2013; 99: 785–90.

44. Park MS, Yoon SJ, Kim YJ, Chung WC. Hip arthroscopy for femoroacetabular impingement: the changing nature and severity of associated complications over time. *Arthroscopy* 2014; 30: 957–63.

45. Polat G, Dikmen G, Erdil M, Asik M. Arthroscopic treatment of femoroacetabular impingement: early outcomes. *Acta Orthop Traumatol Tosc* 2013; 47: 311–7.

46. Roos BD, Roos MV, Junior AC et al. Extracapsular approach for arthroscopic treatment of femoroacetabular impingement: clinical and radiographic results and complications. *Rev Bras Ortop* 2015; 50: 430–7.

47. Zingg PO, Ulbrich EJ, Buehler TC et al. Surgical hip dislocation versus hip arthroscopy for femoroacetabular impingement: clinical and morphological short-term results. *Arch Orthop Traum Surg* 2013; 133: 69–79.