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Time to reconsider the routine use of tourniquets in total knee arthroplasty surgery

AN ABRIDGED VERSION OF A COCHRANE SYSTEMATIC REVIEW AND META-ANALYSIS

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Aims
Many surgeons choose to perform total knee arthroplasty (TKA) surgery with the aid of a tourniquet. A tourniquet is a device that fits around the leg and restricts blood flow to the limb. There is a need to understand whether tourniquets are safe, and if they benefit, or harm, patients. The aim of this study was to determine the benefits and harms of tourniquet use in TKA surgery.

Methods
We searched MEDLINE, EMBASE, Cochrane Central Register of Controlled trials, and trial registries up to 26 March 2020. We included randomized controlled trials (RCTs), comparing TKA with a tourniquet versus without a tourniquet. Outcomes included: pain, function, serious adverse events (SAEs), blood loss, implant stability, duration of surgery, and length of hospital stay.

Results
We included 41 RCTs with 2,819 participants. SAEs were significantly more common in the tourniquet group (53/901 vs 26/898, tourniquet vs no tourniquet respectively) (risk ratio 1.73 (95% confidence interval (CI) 1.10 to 2.73). The mean pain score on the first postoperative day was 1.25 points higher (95% CI 0.32 to 2.19) in the tourniquet group. Overall blood loss did not differ between groups (mean difference 8.61 ml; 95% CI -83.76 to 100.97). The mean length of hospital stay was 0.34 days longer in the group that had surgery with a tourniquet (95% CI 0.03 to 0.64) and the mean duration of surgery was 3.7 minutes shorter (95% CI -5.53 to -1.87).

Conclusion
TKA with a tourniquet is associated with an increased risk of SAEs, pain, and a marginally longer hospital stay. The only finding in favour of tourniquet use was a shorter time in theatre. The results make it difficult to justify the routine use of a tourniquet in TKA surgery.

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Introduction
Over 106,000 total knee arthroplasties (TKAs) were performed in the UK in 2018.1,2 TKA is frequently undertaken with the aid of a tourniquet around the thigh.3 Over 90% of surgeons in the UK, USA, and in Europe routinely use tourniquets for TKA.4 A tourniquet is typically applied at high pressure around the leg for all or part of the procedure.

Tourniquets may help to create a bloodless field, facilitating easier surgery.4 The majority of knee arthroplasty components are cemented in situ to hold and stabilize them in the correct position on the bone.1 Some surgeons believe that using a tourniquet helps reduce bleeding and allows the cement to bond more effectively.4,7 Better cementing should reduce the chance of the knee arthroplasty loosening and failing, but there is no objective clinical evidence to support this. Effective cementing is achieved in hip and shoulder arthroplasty where the use of a tourniquet is not possible. In such surgery it is accepted that the absence of a tourniquet does not compromise the field of view, cause excessive intraoperative blood loss, or lead to long-term problems with implant survivorship.

A tourniquet can cause pain, both during and after surgery.6 In addition, a tourniquet causes both
arterial and venous stasis within the lower leg. It is therefore possible that the use of a surgical tourniquet may increase the risk of postoperative venous thromboembolism (VTE). VTE is one of the most common complications after TKA surgery and a prominent cause of death. Research has found up to 1% develop symptomatic VTE and the in-hospital mortality has been reported as 7.1% in patients with a symptomatic VTE. This is substantially greater than when no VTE was identified (0.3%).

Tourniquets may also cause wound and skin problems. Furthermore, it may be that after tourniquet deflation, systemic emboli formation contributes to the higher than expected incidence of postoperative cognitive deficit following TKA surgery.

The continued use of tourniquets depends on the balance of harms versus benefits they confer to patients. The effects of using a tourniquet in TKA have previously been reported in systematic reviews, most recently in 2014. However, substantial additional data have become available that, when summarized, may have an important impact on clinical practice.

This study aimed to review systematically the evidence to identify the benefits and the harms of surgery with a tourniquet compared to surgery without a tourniquet in patients undergoing knee arthroplasty.

**Methods**

This systematic review and meta-analysis is an abridged summary of a full Cochrane review. It was conducted in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines. The protocol was registered and published with the Cochrane database of systematic reviews. A search of OVID Medline (1946 to 26 March 2020), OVID Embase (1974 to 26 March 2020), and Cochrane Central Register of Controlled Trials via Cochrane Library was performed to identify RCTs. Details of the search strategy can
be found in the Supplementary Material. Trial registries (clinicaltrial.gov and the WHO (World Health Organization International Clinical Trials Registry Platform (ICTRP)) was searched to identify further studies.

Eligibility criteria. We included RCTs and studies in which the allocation to intervention was quasi-randomized (e.g. by date of birth, hospital number). All other study types were excluded including non-randomized trials, cohort studies, and case series.

Population. We included anyone undergoing any type of knee arthroplasty (TKA, revision knee arthroplasty, and unicompartmental knee arthroplasty) for any indication.

Intervention and comparators. We included studies comparing all types of tourniquet used for the full duration or part of the procedure. Comparator groups included: placebo or sham tourniquet (where a tourniquet is applied but not inflated); no tourniquet; and alternative measures to improve field of view or reduce intraoperative blood loss e.g. tranexamic acid. Studies that compared surgery with a tourniquet for the whole procedure versus surgery with a tourniquet for part of the procedure were excluded.

Outcomes. In this abridged review, we present data for the outcomes which were deemed to be medium quality or above. Results from outcomes which were graded as low and very low quality can be found in the full Cochrane review. We assessed the following outcomes: serious adverse events (SAEs; including deep vein thrombosis (DVT), pulmonary embolism (PE), infection, nerve damage, reoperation (excluding revision for implant failure), and mortality); pain (measured using mean pain score or mean change in pain score on a visual analogue scale (VAS), a numeric rating scale or other scale); function (measured with instruments such as Knee Society Score (KSS), Oxford Knee Score (OKS), Hospital for Special Surgery (HSS) knee questionnaire; the planned MCID was 5.3 points in KSS for function); survival of implant (measured as risk of a revision); blood loss (measured with total blood loss, postoperative blood loss, and intraoperative blood loss); duration of surgery; length of hospital stay; and implant stability (using radiostereometric analysis (RSA) as a recognized surrogate marker of later implant failure).21,22

We grouped postoperative outcomes into days for the first week, and then up to three months; three to 12 months; greater than 12 months. Studies not reporting any of the outcomes listed were excluded.

Two review authors (IA, PW) independently screened titles and abstracts, assessed full texts of potentially eligible studies for inclusion, and independently assessed risk of bias for each study using the risk of bias tool in the Cochrane Handbook for systematic reviews and interventions.33 Disagreement was resolved following discussion with a senior author (MU).24

Statistical analysis. We used risk ratios (RRs) with 95% confidence intervals (CIs) to report categorical outcomes. We analyzed continuous data as mean differences (MDs) or as standardized mean differences (SMDs), depending on whether the same scale was used to measure an outcome, along with 95% CIs. We then translated the SMD back to a common scale by multiplying SMD by baseline standard deviation (SD) for the control group from the most representative study.24

For dichotomous outcomes, we calculated the absolute per cent change from the difference in risks between intervention and control groups using GRADEpro (GRADEpro 2015; McMaster University/Evidence Prime, Canada), and we expressed this as a percentage. For continuous outcomes, we calculated the absolute risk difference as improvement in the intervention group minus improvement in the control group, in the original units.

We calculated the relative per cent change for dichotomous data as the RR minus 1, expressed as a percentage. For continuous outcomes, we calculated the relative difference in change from baseline as the absolute benefit divided by the baseline mean of the control group.

For dichotomous outcomes, such as serious adverse events, we calculated the number needed to treat for an additional beneficial outcome (NNTB) from the control group event rate and the risk ratio, using the Visual Rx NNT calculator (Visual RX, UK).

We assessed statistical heterogeneity by visually inspecting the forest plot to assess for obvious differences in results between studies, and by using I² and chi-squared statistical tests.

If we were able to pool more than 10 trials, we decided to undertake formal statistical tests to investigate funnel plot asymmetry. For dichotomous data, we used a weighted linear regression based upon the odds ratio against its variance. In both cases, we considered a p-value below 0.05 as evidence that publication bias was present. We performed analyses using the “meta” R package (R Foundation for Statistical Computing, Austria).

We pooled outcomes of clinically and methodologically homogeneous studies, when meaningful, using a random-effects model. We performed analysis using Review Manager 5 (RevMan 2014, The Nordic Cochrane Centre, Denmark), and we produced forest plots for all analyses. Further details of the data extraction and the statistical analysis plan are detailed in the full Cochrane review.24

Results

The search returned 1,290 citations through the databases and an additional 150 citations from trial registries. Following removal of duplicates, titles and abstracts were screened for eligibility and 53 full texts were assessed for inclusion. In total 41 RCTs met the inclusion criteria for this review. A PRISMA flow diagram of our search results can be seen in Figure 1.

In total 2,819 participants were allocated to either surgery with a tourniquet (n = 1,461) or surgery without a tourniquet inflated (n = 1,466). In the tourniquet group, a tourniquet was used for the entire procedure in all studies. All trials included primary TKA only. In studies reporting sex, 1,777/2,721 (65%) were female. Where studies reported mean age, the mean age was 69.0 (SD 3.95) in the tourniquet group and 68.2 (SD 4.46) in the non-tourniquet group. Further details on the baseline characteristics can be seen in Supplementary Table i.

Risk of bias. Three trials (including a total of 296 patients) met all methodological criteria for low risk of bias.15,16,25 The other trials had sources of bias including unclear risk of selection bias, performance bias, and detection bias, as blinding was not
clearly stated in the methodology or protocol. A risk of bias summary is shown in Figure 2.

**Serious adverse events.** A total of 21 studies reported SAEs (n = 1,799). Of the 901 participants in the tourniquet group, 53 had a SAE, and 26 of the 898 participants in the no tourniquet group had a SAE. The risk of SAEs was greater in the tourniquet group compared to the no tourniquet group (RR 1.73 (95% CI 1.10 to 2.73); Figure 3). The number needed to harm (NNTH) was calculated as 48 (20 to 345) participants needed to have surgery with a tourniquet for one SAE to occur. Table I demonstrates the number of each SAE included in the analysis and the risk ratios.

### Table I. Types of serious adverse events and numbers within each group included in the meta-analysis.

| SAE               | Tourniquet group, n (%) | Non-tourniquet group, n (%) | Risk ratio (95% CI) |
|-------------------|-------------------------|-----------------------------|---------------------|
| DVT               | 26/754 (3.4)            | 11/745 (1.5)                | 1.83 (0.92 to 3.65) |
| PE                | 2/192 (0.52)            | 0/224 (0)                   | 4.51 (0.49 to 41.81) |
| Infection         | 19/427 (4.4)            | 4/419 (0.95)                | 2.17 (1.15 to 6.42) |
| Reoperation       | 9/77 (11.7)             | 5/80 (6.3)                  | 1.63 (0.61 to 4.34) |
| Mortality         | 1/67 (1.5)              | 3/70 (4.3)                  | 0.45 (0.07 to 3.01) |

CI, confidence interval; DVT, deep vein thrombosis; PE, pulmonary embolism; SAE, serious adverse event.

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**Fig. 2.** Risk of bias with judgements about each item presented as percentages across all included studies.

**Fig. 3.** Forest plot demonstrating the number of serious adverse events in the surgery with a tourniquet group compared to the surgery without a tourniquet group. CI, confidence interval. M-H, Mantel-Haenszel method.
In total, 17 studies reported the number of symptomatic venous thromboembolic events (VTE; n = 1,575),8,20–22,31,35–37,39,42–48 There were 27 VTEs in 776 participants in the tourniquet group and 11 VTEs in 799 participants in the non-tourniquet group. Tourniquet use was associated with higher risk of VTE, of borderline statistical significance, compared to surgery without a tourniquet (RR 1.95 (95% CI 0.99 to 3.82); Figure 4). One study reported the number of postoperative asymptomatic DVTs (n = 103). However, these patients did not have any form of chemical thromboprophylaxis and all had routine ultrasounds. As this study was different from the others it was not included in the meta-analysis.41 This study did report significantly higher rate of DVT in the surgery with a tourniquet (54.9%; 28 out of 51 patients) compared to surgery without a tourniquet (25%; 13 out of 52 patients).

**Pain.** Eight studies (n = 577) reported pain using a VAS at day one (scale 0 to 10 with higher scores indicating more pain). The mean pain scores were 1.25 (95% CI 0.32 to 2.19) higher in the tourniquet group (Figure 5),8,13,17,37,39,49–51 Six studies (n = 394) reported pain using a VAS at day two,7,17,49–52 The mean pain scores were 0.37 (95% CI -0.03 to 0.76) higher in the tourniquet group. Ten studies (n = 807) reported pain at day three using the NRS.52 The mean pain scores were 0.78 (95% CI 0.34 to 1.23) higher in the tourniquet group. Figure 5 demonstrates the pain scores in each group at day one, two, and three.

**Function.** Nine studies investigated the effect of tourniquet use on patient reported knee function scores. Four studies (n = 425) reported three-month scores.6,21,38,55 The standardized mean difference between the two groups was 0.64 lower in the tourniquet group (95% CI -1.52 to 0.52) compared to the group without a tourniquet. Five studies (n = 611) participants reported 12 month scores.8,21,35,38,55 The standardized mean difference was 0.06 lower (95% CI 0.22 to 0.10; I² = 0%) in the group with a tourniquet.

**Blood loss.** In total, 18 studies reported overall blood loss in the two treatment groups (n = 1,500).7,8,17,21,35,37,41–43,45,46,48,53,56–59 There was no difference in overall blood loss between patients who underwent knee arthroplasty surgery with and without a tourniquet. The mean difference was 8.61 ml (95% CI -83.76 to 100.97; Figure 6).

**Duration of surgery.** A total of 27 studies reported duration of surgery (n = 1,070),10,16,17,20,21,23,31,35–43,45,47,48,50,53,56,58–61 Surgery with a tourniquet was associated with a shorter length of surgery when compared to the group without a tourniquet. The mean reduction was 3.7 minutes (95% CI -5.53 to -1.87).

**Length of hospital stay.** Overall, 12 studies reported length of stay in patients undergoing knee arthroplasty surgery with and without a tourniquet (n = 995).8,31,35,42,43,45–48,50,53,56,58–61 Surgery with a tourniquet was associated with a longer hospital stay. The mean increase was 0.34 days (95% CI 0.03 to 0.64).

**Implant stability.** Two studies involving 130 patients assessed implant stability using radiostereometric analysis (RSA).18,31 There was no difference in implant maximum total point-motion between the two groups at eight weeks (mean difference (MD) -0.06 mm (95% CI -0.13 to 0.01)), 12 months (MD 0.05 mm (95% CI -0.09 to 0.18)), and 24 months (MD 0.06 mm (95% CI -0.08 to 0.19)).

**GRADE assessment.** The quality of evidence for all outcomes described in this abridged review were graded as moderate. These were downgraded by one level due to risk of bias. Many studies had unclear risk of allocation concealment and unclear risk of participant blinding. For further details on the Grading of Recommendations, Assessment, Development and Evaluation (GRADE; McMaster University/Evidence Prime, Canada) assessment please see ‘summary of findings table’ on the main Cochrane review.24

**Publication bias.** Publication bias was assessed using the aid of funnel plots for all major outcomes. Funnel plots were...
symmetrical for postoperative pain, function, and survival of the implant. Formal statistical tests were performed where more than ten trials were pooled (SAEs, blood loss, duration of surgery, and length of hospital stay). There were no statistically significant signs of publication bias for SAEs (p = 0.318), length of stay (p = 0.922), postoperative blood loss (p = 0.989) and overall blood loss (p = 0.178). There was evidence of publication bias for studies reporting intraoperative blood loss (p = 0.005) and duration of surgery (p = 0.014). Table II shows the results of publication bias testing.

### Discussion

This review of 41 RCTs is the largest of its kind to date and involves 2,819 participants. The findings demonstrate that tourniquet use is associated with increased risk of SAEs, postoperative pain, and longer hospital stay. The only finding in favour of tourniquets was a shorter time in theatre. The perceived benefit of tourniquet use is improved cementing and long-term survival; however, based on evidence from two included studies we found no difference in implant micromotion up to two years postoperatively (as a surrogate marker of longer-term implant survival). It is important to note that only three of the included studies in this review had a low risk of bias, with the remainder having some type of methodological bias. We found no good quality evidence to quantify the direct impact of tourniquet use on implant survival. Further registry-based studies or high-quality trials may answer this question.

The increase in the risk of SAEs (DVT, PE, infection, reoperation, and mortality) related to surgery (RR 1.73 (95% CI 1.10 to 2.73) and NNTH is 48 (95% CI 20 to 345)), which we found are likely to be highly clinically relevant. If our findings are representative, a change in practice to performing surgery without a tourniquet could potentially halve the risk of VTE.

In 2018, 106,000 TKAs were performed in the UK.\(^1\) Based on estimates showing that over 90% of UK surgeons use a tourniquet\(^*\) and a NNTH of 48, a change in practice could potentially prevent around 2,000 SAEs per year in the UK alone. To put these findings further into context a Cochrane review reported that the effect of using antiembolic stockings to prevent postoperative DVT gave an odds ratio of 0.47 (95% CI 0.32 to 0.68).\(^2\)

We acknowledge that the estimates of SAEs are based on a large number of trials with a low number of participants and

### Table 2

| Study or Subgroup | Tourniquet Mean | SD | Total | Weight | Without tourniquet Mean | SD | Total | Weight | Mean Difference | CI | IV, Random, 95% CI | Mean Difference | IV, Random, 95% CI |
|------------------|----------------|----|-------|--------|-------------------------|----|-------|--------|-----------------|----|-----------------|----------------|-----------------|
| 1.2.1 Pain: Day One | 8.1 1.9   | 40 | 4   | 4.6% | 12.61775  | 40 | 4.6% | 1.25 (0.32 to 0.68) |
| Alexanderson 1999\(^*\) | 12.44 1.92 | 38 | 2.79 | 4.5% | 1.09 (0.93 to 2.37) |
| Dong 2019\(^*\) | 5.75 1.45 | 15 | 3.95 | 3.9% | 1.80 (0.88 to 2.72) |
| Kumar 2015\(^*\) | 7.7 1.8 | 30 | 7.4 | 3.3% | 0.30 (0.47 to 1.07) |
| Li 2008\(^*\) | 6.17 1.92 | 56 | 5.32 | 4.9% | 0.85 (0.25 to 1.48) |
| Tai 2012\(^*\) | 5.9 1.92 | 36 | 5.6 | 4.4% | 0.30 (0.46 to 1.05) |
| Subtotal (95% CI) | 289 | 288 | 41.9% | 0.78 (0.34 to 1.23) |

**Fig. 5**

Forest plot demonstrating mean pain scores at day one, two and three. Pain scores were on a ten-point visual analogue scale (lower is better). CI, confidence interval; IV, inverse variance method; SD, standard deviation.
Forest plot demonstrating the overall blood loss in the surgery with a tourniquet group versus the surgery without a tourniquet group. CI, confidence interval; IV, inverse variance method; SD, standard deviation.

| Study or Subgroup | Tourniquet | Without tourniquet | Mean Difference | Mean Difference |
|-------------------|------------|--------------------|----------------|----------------|
| Abdel-Salem 1995* | 800        | 276.87             | 40             | 805            | 235.365         | 40             | 5.7% | -5.00 (-117.61 to 107.61) |
| Aglietti 2000*    | 640        | 120                | 10             | 627            | 42              | 10             | 5.9% | 13.00 (-65.80 to 91.80) |
| Dong 2019*        | 455.45     | 69.47              | 64             | 258.34         | 40.85           | 58             | 6.2% | 197.11 (177.11 to 217.11) |
| Goel 2019*        | 966.64     | 260.91             | 100            | 1,146.02       | 237.03          | 99             | 6.0% | -181.38 (-260.63 to -112.13) |
| Huang 2017*       | 734.5      | 274.2              | 50             | 627.7          | 198.1           | 50             | 5.8% | 106.80 (13.04 to 200.56) |
| Juelsgaard 2005* | 1,286      | 725                | 16             | 1,056          | 272             | 14             | 2.9% | 770.00 (368.99 to 1171.01) |
| Ledin 2012*       | 1,194      | 346                | 25             | 1,236          | 348             | 25             | 4.8% | -52.00 (-244.64 to 140.64) |
| Li 2008*          | 545        | 276.87             | 30             | 624            | 235.365         | 30             | 5.5% | -79.00 (-209.04 to 51.04) |
| Li 2009*          | 1,298      | 285                | 40             | 1,117          | 221             | 40             | 5.7% | 181.00 (69.24 to 292.76) |
| Mori 2016*        | 470        | 219                | 51             | 771            | 295             | 52             | 5.9% | -291.00 (-382.96 to -191.04) |
| Pfohn 2014*       | 900        | 276.87             | 45             | 600            | 235.365         | 45             | 5.7% | 300.00 (183.83 to 406.17) |
| Tai 2012*         | 303        | 119                | 36             | 423            | 197             | 36             | 6.0% | -120.00 (-195.18 to -44.82) |
| Tetro 2001*       | 654        | 224                | 33             | 742            | 287             | 30             | 5.3% | -88.00 (-238.89 to 62.89) |
| Vandenbussche 2001* | 1,234.9      | 276.87             | 40             | 1,557.4        | 235.365         | 40             | 5.7% | -322.50 (-435.11 to -209.89) |
| Wu 2018*          | 1,703.95   | 201.93             | 50             | 1,093.66       | 251.98          | 50             | 5.9% | 64.09 (25.14 to 153.59) |
| Yavarka 2010*     | 795        | 266                | 22             | 810            | 244             | 29             | 5.4% | -15.00 (-157.27 to 127.27) |
| Zhang 2010*       | 1,360      | 237                | 30             | 1,290          | 279             | 30             | 5.5% | 70.00 (-61.00 to 201.00) |
| Zhou 2010*        | 314.5      | 165.3              | 72             | 393.2          | 178.3           | 68             | 6.1% | -14.70 (-31.74 to 42.34) |

Total (95% CI) 754   746 100.0% 8.61 (-83.76 to 100.97)

Heterogeneity: Tau² = 35816.17; Chi² = 401.67, df = 17 (P < 0.00001); I² = 96%

Test for overall effect: Z = 0.18 (P = 0.86)

| Outcome                  | Bias estimate (SE) | p-value* |
|--------------------------|-------------------|----------|
| Serious adverse events   | 0.567 (0.552)     | 0.318    |
| Pain                     | 3.875 (2.168)     | 0.097    |
| Intraoperative blood loss| -8.732 (2.596)    | 0.005    |
| Overall blood loss       | 5.585 (3.968)     | 0.178    |
| Postoperative blood loss | -0.049 (3.420)    | 0.989    |
| Transfusion rate         | 0.47 (0.63)       | 0.468    |
| Length of stay           | 0.219 (2.182)     | 0.922    |
| Duration of surgery      | -2.947 (1.113)    | 0.014    |

*For continuous data, (pain, blood loss, length of stay, and duration of surgery) we tested asymmetry by using a weighted linear regression of the standardised mean against its standard error. For dichotomous data (serious adverse events and transfusion), we used a weighted linear regression based upon the odds ratio against its variance. In both cases, we considered a p-value below 0.05 as evidence that publication bias was present.

MCID. However, this may still be relevant as it is well established that an early rise in postoperative pain increases the risk of persistent chronic pain.56,56 Chronic pain remains a problem in a substantial portion of patients having TKA.66

There was no evidence of a difference in overall blood loss, function, or implant stability. Surgery with a tourniquet was associated with an increased length of hospital stay (mean increase 0.34 days (95% CI 0.03 to 0.64)) which may be clinically relevant to patients, surgeons, and healthcare providers. Over a year based on 106,000 TKAs performed per year, this would equate to 36,040 excess bed days. The cost of one excess bed day is £346, which could be extrapolated to an excess annual cost of £12,469,840 due to the use of a tourniquet.67 TKA with a tourniquet was associated with a reduced duration of surgery (~3.7 minutes (95% CI -5.53 to -1.87)). This equates to 6,537 hours less when a tourniquet is used compared to no tourniquet over one year. The cost of operating theatre time has been shown to cost £1,200 per hour.68 By using a tourniquet, this could save the NHS £7,844,000 per year in terms of operating time. When combining both economic outcomes, very crudely, the use of a tourniquet could potentially cost the NHS £4,625,840 per year.

There have been four previous systematic reviews between 2010 and 2014.12–14 Our findings are consistent with but add substantially to the most recent review in 2014 by Zhang et al.4 They reported on 13 RCTs involving 689 participants and showed no significant difference in overall blood loss but an increased risk of thrombotic events (RR 5.0 (95% CI 1.31 to 19.10)) and non-thrombotic complications (RR 2.03 (95% CI 1.12 to 3.67) in the surgery with a tourniquet group. Since completing this search, a recent RCT has been published which has similar findings to our review, including higher postoperative pain scores in the tourniquet group and reduced duration of surgery. This study also found that surgery with a tourniquet was associated with significantly lower patient reported knee function and range of motion at three weeks.69
If further trials are needed, they should focus on evaluating the risks of systemic emboli on cognitive function, and health-related quality of life. Ideally, prospective registry type data may facilitate more precision in estimating implant survival. Further research into the impact of tourniquet use in revision knee arthroplasty should also be considered in line with a recently established research priorities.70

Using a tourniquet during knee arthroplasty surgery is a practice that has largely been unchallenged until recently, with a focus on the benefits, but very little on the potential harms. The evidence presented from our data synthesis shows substantial risks and no major advantage to patients, which questions the routine use of a tourniquet in TKA.

**Take home message**
- The results demonstrate that the use of a tourniquet in total knee arthroplasty surgery is associated with increased risks to the patient, including serious adverse effects and increased levels of postoperative pain.
- There is no evidence to suggest any major advantage to the patient in the use of a tourniquet for these procedures.
- These findings suggest that the risks of tourniquet use should be strongly considered prior to their use.

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**Supplementary material**
Results of search strategy and baseline characteristics of the included studies.

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I. Ahmed: Designed the study, Performed the search, Screened abstracts and full texts, Extracted and analyzed the data, Produced and revised the final manuscript.
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Data may be made available upon reasonable request.

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Ethical review statement:
Patient members were involved at all stages of this review. Three patient members were part of the Safety and Feasibility Evaluation of Knee Replacement Surgery (SAFE-TKR) Study patient advisory group: Mrs Jan Dixon, Mrs Christine Goulden and Mr James Smith. Prior to starting the review, the aims and outcomes of interest were discussed with the group. The PPI group agreed that the outcomes studied were of substantial clinical importance. The results have also been discussed with this group and a plain language summary was produced. This summary is freely available as part of the main Cochrane review.

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