Hip and Knee Section, Prevention, Surgical Technique: Proceedings of International Consensus on Orthopedic Infections

Article *in* The Journal of arthroplasty · October 2018

DOI: 10.1016/j.arth.2018.09.015

The Journal of Arthroplasty 34 (2019) S301–S307

Contents lists available at ScienceDirect

The Journal of Arthroplasty

journal homepage: www.arthroplastyjournal.org

Hip and Knee Section, Prevention, Surgical Technique: Proceedings of International Consensus on Orthopedic Infections

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ARTICLE INFO

Article history:
Available online 19 October 2018

Keywords:
tourniquet
tourniquet time
tourniquet pressure
total knee arthroplasty
surgical approach
total knee arthroplasty surgical approaches
parapatellar approach
subvastus approach
surgical site infection (SSI)
periprosthetic joint infection (PJI)
total hip arthroplasty surgical approach
direct anterior approach
posterior approach
minimally invasive total hip arthroplasty
posterolateral approach
periarticular injections
unilateral arthroplasty
simultaneous bilateral arthroplasty
staged bilateral arthroplasty

Question 1: Does the use of a tourniquet influence the rates of surgical site infections/periprosthetic joint infections (SSIs/PJIs) in primary or revision TKA?

Recommendation:

The literature is inconclusive regarding the use of tourniquet during total knee arthroplasty and its potential to increase the risks for surgical site infections/periprosthetic joint infections (SSIs/PJIs) in TKAs. Tourniquet times and pressures should be minimized to reduce this risk.

Level of Evidence: Limited

Delegate Vote: Agree: 89%, Disagree: 9%, Abstain: 2% (Super Majority, Strong Consensus)

Rationale:

The use of a pneumatic tourniquet during total knee arthroplasty (TKA) has long been a standard for this procedure. However, concerns have arisen over the ischemic injury that can occur from tourniquet use. This has prompted many authors to conduct studies evaluating the use and nonuse of a tourniquet and its effect on perioperative blood loss, postoperative pain and function, and postoperative complications [1–7]. However, many of these studies are small, randomized, controlled trials that lack the power to definitively state the influence of tourniquet use of surgical site infections (SSIs) and periprosthetic joint infections (PJIs).

Liu et al [8] showed in a randomized controlled trial of 52 patients undergoing simultaneous bilateral TKA that tourniquet use was associated with greater wound ooze and blistering, as well as the only deep infection in the cohort occurring in a TKA case that had been performed while using a tourniquet. In a 31-patient randomized controlled trial, Clarke et al [9] demonstrated that increased tourniquet pressures led to sustained wound hypoxia up to 1 week after surgery. A meta-analysis by Yi et al [6] evaluated 13 randomized controlled trials of tourniquet use comprising 859 patients. Of these 13 studies, 3 evaluated infection risk, SSI, and PJI together, and they found that tourniquet use was significantly associated with an increased risk of infection. A meta-analysis by Zhang et al [10] found a similar pooled result with tourniquet use associated with a greater risk of nonthrombotic complications, infection included.

Longer tourniquet times, and by virtue longer surgical times, have been associated with an increased risk for both SSI and PJI [11–13]. Willis-Owen et al [11] in a series of 3449 consecutive TKA found that patients who went on to have a SSI/PJI had significantly

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to https://doi.org/10.1016/j.arth.2018.09.015.

[1] Question 3.
[2] Question 2.
[3] Question 1.
[4] Question 5.
[5] Question 4.

https://doi.org/10.1016/j.arth.2018.09.015

longer tourniquet times than noninfected patients. Ricciardi et al [12] found a similar result in their analysis of perioperative variables affecting 30-day readmission. Na et al [14] evaluated early release of the tourniquet following cementation of components vs reinflation of the tourniquet after controlling bleeding in 206 patients and found that the increased tourniquet time for patients in the reinflation group did not affect the rate of wound complications, SSI, or PJI. However, none of these studies were able to propose a cutoff for tourniquet time over which the risk of SSI and PJI begins to increase. These studies also did not differentiate between operative time and tourniquet time. As increased surgical time is a known risk factor for SSI and PJI, the confounding effect of increased surgical time may be influencing the relationship between tourniquet time and postoperative infections.

There is still much debate over the efficacy of tourniquet use to decrease perioperative blood loss. Ledin et al [15] conducted a randomized controlled trial on 50 consecutive TKAs on the use of a tourniquet and found no difference in calculated perioperative blood loss. The meta-analysis by Zhang et al [10] found that calculated blood loss was greater without the use of a tourniquet; however, this did not result in a greater transfusion requirement. Conversely, a meta-analysis by Jiang et al [16] found that tourniquet use did decrease transfusion requirement in the pooled analysis of 1450 knees. As allogeneic blood transfusion is a known risk factor for SSI and PJI, limiting blood loss is an important aspect of infection prevention [17–20].

Another concern with the use of a tourniquet during TKA is whether appropriate antibiotic prophylaxis is administered to the surgical site. Friedman et al [21] evaluated soft tissue and bone concentrations of antibiotics given 1 minute, 2 minutes, and 5 minutes before tourniquet inflation and found the highest concentrations when antibiotics were administered 5 minutes before inflation. Yamada et al [22] found that when cefazolin was administered 15 minutes before inflation, the concentration in the bone and soft tissue at the surgical site was above the MIC90 for methicillin-sensitive *Staphylococcus aureus*, but below the MIC90 for cephazolin-resistant coagulase-negative staphylococcal species. Young et al [23] found that by administering antibiotic prophylaxis intraosseously, higher regional antibiotic concentrations could be achieved; however, the clinical efficacy of this in reducing the rates of SSI and PJI still need to be evaluated.

The effect that the use of a tourniquet has on the incidence of SSIs and PJIs after TKA has not been fully evaluated. The randomized controlled trials of this subject have been of small cohorts of patients that lack the power to evaluate these complications. The meta-analyses on this topic also have not been able to definitively comment, as many studies did not report the incidence of SSI and PJI in their cohorts. Moving forward, studies evaluating the use of a tourniquet during TKA should consider SSI and PJI as a secondary end point so that future pooled analyses may be better able to elucidate a connection, if one exists.

Question 2: Does the surgical approach (parapatellar vs subvastus) during primary TKA affect the incidence of subsequent surgical site infections/periprosthetic joint infections (SSIs/PJIs)?

Recommendation:

The incidence of surgical site infections/periprosthetic joint infections (SSIs/PJIs) after primary total knee arthroplasty (TKA) is not influenced by the surgical approach (parapatellar vs subvastus).

Level of Evidence: Moderate

Delegate Vote: Agree: 97%, Disagree: 1%, Abstain: 2% (Inanimous, Strongest Consensus)

Rationale:

The medial parapatellar approach and the subvastus approach are the most common approach techniques for primary total knee arthroplasty (TKA) [24]. To date, the question of the best surgical approach for primary TKA is still a matter of debate [25]. Despite the vast body of literature investigating the clinical outcome of patients undergoing TKA with either the medial parapatellar or the subvastus approach, only a limited number of studies focus on their infection rates.

There have been 4 meta-analyses published to date that compare the subvastus to the medial parapatellar approach as well as 1 meta-analysis that compares subvastus to quadriceps-sparing approach, which are included for reference below [24,26–29]. Regarding infection risk, none of these 5 meta-analyses found a difference.

Question 3: Does the surgical approach of primary THA affect the incidence of subsequent surgical site infections/periprosthetic joint infections (SSIs/PJIs)?

Recommendation:

The surgical approach in primary THA does not affect the incidence of subsequent surgical site infections/periprosthetic joint infections (SSIs/PJIs).

Level of Evidence: Strong

Delegate Vote: Agree: 88%, Disagree: 10%, Abstain: 2% (Super Majority, Strong Consensus)

Rationale:

Many approaches to expose the hip joint have been described. Surgical approaches for total hip arthroplasty (THA) have evolved to include a minimally invasive posterior approach to minimize soft tissue damage, a resurgence of the direct lateral approach to address concerns of instability, and the increased popularity of direct anterior surgery to improve postoperative recovery. Smaller skin incisions combined with less soft tissue damage and improved pain management techniques have resulted in faster recovery times, quicker rehabilitation, and shorter hospital admissions. However, the impact of these approaches on the risk of infection has not been studied extensively. We report data from randomized control trials (RCTs) and large registry databases to support our conclusions.

In the English literature, 37 RCTs were found comparing functional and other postoperative results using different surgical approaches for primary THA. None of these, however, was designed to study periprosthetic joint infection (PJI) as the primary outcome. Fortunately, PJI is frequently reported as a secondary outcome. More than half of the RCTs identified (20/37 RCTs) compared a conventional approach to a minimally invasive approach (“mini”), 12 studied 2 conventional approaches, and 5 evaluated 2 mini-approaches. The posterolateral (PL) approach in both its standard or minimally invasive iterations was the most frequently examined (22 RCTs). The primary outcome in the majority (30/36) of these RCTs was the functional assessment of the patients. The sample size of RCTs ranged from 20 to 219 THAs.

In the RCT with the greatest reported sample size, Ogonda et al [30] followed up 219 patients operated through either a standard or minimally invasive PL approach for 6 weeks. No infections were observed in the standard posterior approach (PA) group, while one deep and one superficial infection were found in the minimally invasive surgery group. In another report, Xie et al [31] studied 92 patients with unilateral primary osteoarthritis who were randomized to undergo a THA using either a supercapsular, percutaneously assisted approach or a conventional PL approach. An intention-to-treat analysis was used, but no infection was noticed in either group. Kim [32] reported one infection in a study in which a mini-posterior approach was compared to a standard PL group. Goosen et al [33], in a RCT of 120 THAs, described one infection in the “classic” group and no infections in their “minimally invasive surgery” group. Owing to the low incidence of PJI, these trials did not have the statistical power to evaluate the relationship between surgical approach and surgical site infection (SSI)/PJI.

Eight meta-analyses [34–41] of these RCTs have been conducted to compare postoperative results of primary THA when using different surgical approaches: 3 compared "mini" approaches to standard ones [37,39,40], 1 compared mini vs standard PL [36], 1 compared a direct lateral (DL) vs the direct anterior (DA) approach [38], 2 compared PL vs DA approach [34,35], and 1 compared DA, PL, lateral approaches (including the Watson-Jones and modified Hardinge approaches), and 2 compared incision surgery [41]. Two of these 8 meta-analyses [35–40] were designed to specifically report significant differences in the complication rates between surgical approaches. Putananon et al [41] performed a network meta-analysis of 14 RCTs (1017 patients) comparing DA, PL, lateral, and 2 incision [41] approaches and concluded that PL had the lowest risk ratio for overall complications including infection. The systematic review and meta-analysis of Miller et al [34] were designed to compare postoperative complications of prospective and retrospective studies between DA and PL approaches. A total of 7 of the 19 studies included reported results on infection; 6 of them were comparative studies, and 1 was a registry paper. The PJI rate was reported as 0.2 events per 100 person-years for DA approach and 0.4 events for PL approach; this difference was statistically significant (risk ratio [RR] = 0.55, $P = .002$). However, when only the comparative studies were included in the analysis, this difference ceased to be significant (RR = 0.65, 95% confidence interval 0.16-2.7).

Registry data have been published that specifically looked at risk factors for revision and included surgical approach and its impact on infection risk. Owing to the size of the data sets involved, registries can adjust the results to account for the impact of variables such as obesity, diabetes, and hospital volume on outcomes. Recently, Smith et al [42] retrospectively evaluated 91,585 THAs from the New Zealand Registry to identify factors that affected the infection rate after THA. Multivariate analysis revealed that the anterolateral (AL) approach significantly increased the PJI revision rate at 12 months when compared with the PL approach (odds ratio = 1.61, $P = .005$). In another study, Mjaaland et al [43], analyzing 21,860 THAs from the Norwegian Registry showed a significant increase in the risk of revision due to PJI when the DL approach was used, compared to DA and AL approaches (RR = 0.53) and the PL approach (RR =1 0.57). However, a study [44] from the Swedish Registry showed no difference in the infection rate of 90,662 THAs using either PL or AL approach, but it should be noted that no adjustment was made for obesity, diabetes mellitus, or American Society of Anesthesiologists score. In agreement with the Swedish data is a study by Namba et al [45] which looked at 30,491 THAs in the Kaiser Permanente Registry and did not find an association between SSI and surgical approach when adjusting for a large number of covariates such as the use of antibiotic cement, surgeon volume, age, diabetes, body mass index, American Society of Anesthesiologists score, and a number of other factors. However, the Kaiser Permanente Registry was composed predominantly of patients undergoing PL THA and may not have the data to comment the other approaches. Christensen et al [46] compared 1288 PL THAs to 505 DA patients recorded in a private registry and found a much higher incidence of wound complications that required reoperation in the DA group (1.4% vs 0.2%, $P = 007$), but the incidence of SSI (2 in DA and 1 in PA) and PJI (1 in each group) was comparable.

Finally, we note that obesity (a risk factor for both SSI and PJI after THA [42,45]) may impact the relative risk of any specific surgical approach on infection. Watts et al [47] stated that obesity is a stronger risk factor when the DA is used. Dowsey and Choong [48] reviewed over 1000 patients undergoing PL or DL THA. The infection rate was higher in obese than in nonobese patients when PA was used (2.5% obese and 18% morbidly obese patients), but they found no significant correlation between the DL approach and obesity. Christensen et al [46] compared 1288 PA THAs to 505 DA patients and found a much higher incidence of wound complications that required reoperation in the DA group (1.4% vs 0.2%, $P = 007$), but the incidence of SSI (2 in DA and 1 in PA) and PJI (1 in each group) was comparable.

In conclusion, surgical approach does not affect the risk of SSI/PJI after primary THA. While some data exist indicating the DL and AL approaches may be at an increased risk of SSI/PJI, the data are by no means definitive. Furthermore, much of the existing data are derived from registries, which have been shown to underreport the incidence of infection [49–51]. More granular data are required to make a more informed conclusion on this topic.

Question 4: Does the use of periarticular injections affect the rate of surgical site infections/periprosthetic joint infections (SSIs/PJIs) recurrence in reimplantation?

Recommendation:

Unknown. Periarticular injections are an effective adjunct treatment for pain control following primary total joint arthroplasty, but their effectiveness and impact on the rates of surgical site infections/periprosthetic joint infections (SSIs/PJIs) in the revision setting has not been investigated. The use of periarticular injections at the time of reimplantation can be performed at the surgeon's discretion.

Level of Evidence: Limited

Delegate Vote: Agree: 91%, Disagree: 5%, Abstain: 4% (Super Majority, Strong Consensus)

Rationale:

Pain management after primary and revision total joint arthroplasty (TJA) is crucial to facilitate early mobilization, decrease length of stay, decrease opioid consumption, and to improve patient satisfaction [52]. It is known that revision TJA cases such as prosthesis reimplantation are more complex and typically require greater dissection than primary TJA; thus, postoperative pain control may be more difficult.

Periarticular injections (PAIs) of anesthetic medications are a proven, effective adjunct to multimodal pain management protocols in the primary TJA setting [52–54]. While the combination of medications injected varies widely among randomized controlled trials, PAIs have been shown to provide superior pain control vs the use of patient-controlled anesthesia [55] and femoral nerve blocks [56–58], and PAIs are equivalent to the use of a femoral-sciatic nerve block after primary total knee arthroplasty [59]. In a systematic review of 13 randomized controlled trials of patients undergoing primary total hip arthroplasty, Marques et al [52] found patients receiving local anesthetic infiltration to have a greater reduction in pain at 24 and 48 hours postoperatively. However, the impact of PAIs on pain management in the revision TJA setting, along with their impact on the rate of surgical site infection (SSI)/periprosthetic joint infection (PJI), has not been investigated.

One consideration is whether corticosteroid should be included in the use of a PAI. There is conflicting evidence as to whether inclusion of corticosteroid in a PAI improves pain control [60–63]. Furthermore, there is the theoretical concern of a potentially increased risk of infection with the inclusion of corticosteroid given its immune-modulating properties [64,65]. No studies in the setting of primary arthroplasty have found a significant difference in SSI rates in PAI containing corticosteroid, and it is worth noting that all these studies were powered using pain as a primary outcome [60,64,66,67]. Thus, these studies were not designed to determine the influence of corticosteroid on an outcome of low incidence such as SSI/PJI, and the risk posed by intraoperative corticosteroid PAI remains theoretical.

Unfortunately, there are no studies that assess the impact of PAIs on the rates of SSIs/PJIs recurrence during TJA reimplantation. As

PAIs assist with pain control in the primary setting, it could be presumed that they are effective during TJA reimplantation, yet this has not been proven. The use of PAIs at the time of reimplantation can be performed at the surgeon's discretion, but the addition of corticosteroid should be cautioned as its immunomodulating risk may outweigh its questionable benefit. Studies investigating the influence of PAI on the incidence of SSI/PJI after primary and revision arthroplasty are needed.

Question 5: Does simultaneous bilateral hip or knee arthroplasty increase the risk of subsequent surgical site infections/periprosthetic joint infections (SSIs/PJIs) compared to unilateral or staged bilateral arthroplasty?

Recommendation:

Simultaneous bilateral hip or knee arthroplasty does not increase the risks of surgical site infections/periprosthetic joint infections (SSIs/PJIs) compared with unilateral or staged bilateral arthroplasty.

Level of Evidence: Moderate

Delegate Vote: Agree: 79%, Disagree: 15%, Abstain: 6% (Super Majority, Strong Consensus)

Rationale:

Since Jaffe and Charnley reported the first simultaneous bilateral total hip arthroplasty (THA) in 1971 [68], and Ritter and Randolph performed the first detailed study of the functional outcome in 1976 [69], there has been ongoing discussion regarding the advantages and disadvantages of simultaneous bilateral procedures in the patients with bilateral arthritis.

In the absence of a randomized and prospective trial with an adequately powered sample to compare the infection rates in simultaneous bilateral joint arthroplasty with staged bilateral total arthroplasty, knowledge regarding infection rates mostly comes from retrospective studies. Many of these studies are biased, by selection bias, misclassification bias, and/or follow-up time bias. Studies analyzing large numbers of patients allow for comparisons to be made regarding complications that occur infrequently, such as infection, but the validity of these comparisons is not known [70].

The reviews of the studies that analyze the probabilities of developing periprosthetic joint infection after simultaneous bilateral total arthroplasty have reported contradictory results. There have been 3 meta-analyses in recent years, in which the outcomes of simultaneous bilateral total knee arthroplasty (SBTKA) have been compared with staged bilateral TKA. Hu et al [71] and Hussain et al [72] concluded that the infection rates were similar between the 2 groups. Other studies did not observe differences in the infection rates between simultaneous and unilateral or staged bilateral TKA [73–82]. On the other hand, Fu et al [83] in another meta-analysis concluded that SBTKA was associated with a lower infection rate. Similarly, Poultsides et al [84] published the only study focused on comparing the rate of infection in a long retrospective series of patients undergoing SBTKA, staged bilateral TKA, or unilateral TKA. They observed that the overall infection rate after simultaneous bilateral TKA (0.57%) was lower compared with the staged (1.39%) or unilateral (1.1%) cohorts. The rate of superficial infection was significantly lower in the simultaneous cohort (simultaneous: 0.28% vs staged: 1.04% vs unilateral: 0.87%; $P = .003$), but the rate of deep infection was similar among the groups (simultaneous: 0.32% vs staged: 0.35% vs unilateral: 0.24%; $P = .65$).

Meehan et al [85] used a more sophisticated epidemiologic methodology in an attempt to minimize the selection bias inherent in most published studies. They analyzed the California Patient Discharge database to create an intention-to-treat cohort of patients who originally were scheduled to undergo separate-admission staged bilateral total knee arthroplasty. Important findings included that the SBTKA cohort had significantly lower risks of periprosthetic joint infection (odds ratio = 0.6 [95% confidence interval, 0.5-0.7]; unadjusted rate, 8.7 per 1000 for the SBTKA cohort compared with 16.5 per 1000 for the separate-admission staged bilateral total knee arthroplasty cohort).

In a retrospective study [86], simultaneous bilateral knee arthroplasty, compared with the unilateral knee arthroplasty, was associated with increased superficial wound infection (6.0 vs 0.7%; $P = .003$) and deep prosthetic infection (3.5% vs 0.7%; $P = .02$). The rationale behind these studies is that the prolonged operative time, an increased blood loss, an increased number of assistants in the operating room, changing instruments during bilateral TKA and THA, and no redraping or rescrubbing may predispose these patients to a higher rate of infection [86,87]. Della Valle et al [88] did not demonstrate a statistically significant difference in the rate of deep or superficial infections among patients undergoing simultaneous hip arthroplasty using different or the same set of surgical instruments, arguing that the use of the same set of instruments for the second side arthroplasty appeared to be safe.

Shao et al [89] found in their meta-analysis 4 studies that provided data on infectious complications (including deep and superficial infection), and the pooled data showed a statistically higher infection rate in simultaneous vs staged bilateral THA (odds ratio = 2.17; 95% confidence interval = 1.27-3.71; $P = .004$). In the same way, Berend et al [90] reported a surgical site infection complication rate of 1.8% for simultaneous bilateral THA, which was significantly higher than the rate for staged bilateral THA. However, Della Valle et al [88] observed a 0.1% infection rate for simultaneous bilateral THA using the same lateral decubitus position.

Other studies comparing simultaneous bilateral THA and unilateral THA did not find increased rates of surgical site infection [91–93]. There is only one [94] prospective, randomized, controlled study in literature comparing simultaneous bilateral and staged hip arthroplasties, and no significant difference was found in the incidence of infection between the 2 hip arthroplasty groups.

It is well known that simultaneous bilateral total joint arthroplasty is associated with increased blood loss and need for allogeneic blood transfusion compared to unilateral or staged bilateral arthroplasty [75,90–92,94–103]. Pulido et al [104] found, after multivariable logistic regression analysis in a retrospective study, that simultaneous bilateral surgery (compared with unilateral procedures) that the transfusion of allogenic blood units were independent predictors of periprosthetic joint infection after primary joint arthroplasty. Nevertheless, there is contradictory evidence in the different studies on the relationship between allogeneic transfusions and the risk of periprosthetic infection [20,105–107].

Having evaluated all available published reports, we believe that the incidence of infection after bilateral total joint arthroplasty performed under the same anesthesia is not significantly higher than the rate of infection after unilateral or staged bilateral TJA.

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