

Original Research Article

A comparison of blood loss and the need for transfusion following primary total knee replacement with or without the use of a tourniquet

Sayyied J. Kirmani^{1*}, Mark Middleton¹, Andreas Fontalis¹, Raka Srivastava², Feroz Dinah³

¹Department of Trauma and Orthopaedics, St. Georges Hospital, Tooting, London, UK

²Department of Anaesthetic, ³Department of Trauma and Orthopaedics, South West London Elective Centre, Epsom, London, UK

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*Correspondence:

Dr. Sayyied J. Kirmani,

E-mail: ymmij26@hotmail.com

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ABSTRACT

Background: Primary total knee replacement (TKR) has traditionally been carried out with the use of a tourniquet. More recent trends towards performing the surgery without a tourniquet have had some support in the literature and may improve patient recovery.

Methods: A retrospective cohort of 198 consecutive primary TKRs from our institution were identified and analysed, 52 used a tourniquet and 146 did not. All TKRs also utilised a standardised interventions protocol including withholding of anticoagulants and antiplatelet medications, topical adrenaline injection, and both IV and topical tranexamic acid. Outcomes measured were estimated intra-operative blood loss, overall blood loss through comparison of pre and post-operative haemoglobin laboratory values, and the need for post-operative blood transfusion.

Results: Analysis demonstrated a statistically significant reduction in estimated intra-operative blood loss when a tourniquet was used ($p < 0.001$). However, overall blood loss indicated by the haemoglobin drop after surgery was not significantly affected by tourniquet use ($p = 0.342$). Transfusion requirements were also similar among the groups (4.8% vs. 5.8%) and no tendency was suggested towards an increased rate of transfusion in the non-tourniquet group.

Conclusions: Our study shows that although estimated intra-operative blood loss is increased without a tourniquet, total blood loss as measured by haemoglobin levels is no different for primary TKRs that use a tourniquet and those that do not. Furthermore there is no difference in post-operative blood transfusion rates. It is our hope that this study will add to the body of evidence for surgeons to consider no longer using a tourniquet for primary TKR.

Keywords: Knee replacement, Tourniquet, Blood loss

INTRODUCTION

Total knee replacement (TKR) is an extremely common operation with nearly 70,000 performed each year in the UK.¹ With an increasingly ageing population, demands for this surgical intervention are likely to rise. TKR has traditionally been carried out with the use of a tourniquet placed in a proximal thigh position and set to a pressure of 300 mmHg for either the entirety or part of the

operation. The benefits of using a tourniquet are often quoted as a reduction in blood loss during the operation and a reduction in the operative time by allowing the surgeon a bloodless operative field.^{2,3} It is also thought to improve the cementing technique during prosthetic implantation as the bloodless field permits better penetration of cement into bone.^{4,5} However these presumptions have been questioned.

There is an increasing body of evidence that tourniquet use may be of no benefit, and perhaps cause harm.²⁻⁹ Modern surgical techniques have contributed to better intra-operative haemostasis and thus reduced the requirement for a tourniquet. Such techniques include judicious diathermy usage during surgery. Furthermore permissive hypotension can be maintained using a more limited fluid provision and precise anaesthetic control of blood pressure during the operation.¹⁰⁻¹² Pro-thrombotic agents such as tranexamic acid can be given intravenously or topically.¹³⁻¹⁶ It also includes the use of local anaesthetic agents mixed with adrenaline that are given at various stages of the operation.^{17,18}

Improved pain scores when a tourniquet has not been used have been documented. This is presumed to be due to the lack of ischaemic injury to the limb as well as the crush injury to the musculature.¹⁹⁻²¹ There is also recent evidence that when a tourniquet is not used the quadriceps musculature maintains a greater degree of strength, and the knee has a better range of movement.²⁰⁻²² These factors can all improve patient recovery.^{22,23}

The above findings and modern surgical and anaesthetic techniques have resulted in a trend to reduce the tourniquet time or even perform the surgery without a tourniquet. The purpose of our study was to compare blood loss and the need for transfusion in primary total knee replacement performed with or without a tourniquet. Our hypothesis was that there would be no difference in overall blood loss when implementing our standard practices for TKR without a tourniquet.

METHODS

We conducted a retrospective cohort study of all primary cemented TKRs carried out in our institution over a 13-month period (1st June 2016- 30th June 2017).

Our inclusion criteria was that of any standard primary cemented TKRs carried out by three surgeons (D, K, M) who are experienced in both using and not using tourniquets.

Our exclusion criteria included all cases described as revision, partial, complex and bilateral TKRs, along with any cases where intra-operative blood transfusion was used, as such cases could not reflect the blood loss from the surgery itself with post-operative haemoglobin (Hb) measurements.

Using the aforementioned criteria, 198 cases were identified and their clinical notes were reviewed using our electronic database (BlueSpier). These patients were then divided into two cohorts depending on whether a tourniquet was used or not. For the purpose of our study any use of a tourniquet during the procedure put the patient in the tourniquet group. On reviewing the pre-operative assessment notes, all patients who were on anticoagulant medication (including corticosteroids), as

well as any patients who had an underlying bleeding disorder were identified, and were a considered part of the analysis.

All primary TKRs in our institution undergo several standard interventions that have a bearing on blood loss during the operation.

Anti-coagulants are maintained or stopped prior to surgery as per a standard protocol. Low dose (75 mg) aspirin and corticosteroids can be continued up to and beyond the time of the operation. Dipyridamole is discontinued 48 hrs before the operation, while Factor Xa inhibitors like rivaroxaban and apixaban are discontinued 3 days before surgery. Warfarin is stopped 5 days before surgery, with conversion to dalteparin if bridging anti-coagulation is required. Clopidogrel is stopped 7 days before surgery.

A long acting local anaesthesia with adrenaline mix is injected intra-operatively. This consists of 150 ml of 2 mg/ml Naropin, with 1 ml of 1 in 1000 adrenaline, and 1 ml of 30 mg/ml ketorolac if renal function allows. This mixture is given at the start of the operation with 50 ml subcutaneously. A further 50 ml is infiltrated into the posterior joint capsule after the bony cuts have been made, and a final 50mls is infiltrated into the musculature and subcutaneous tissue during wound closure.

One gram of tranexamic acid is given intravenously 10 minutes before surgery is commenced. A further gram of topical tranexamic acid in 100 ml of normal saline is applied topically while the cement was curing.

Our orthopaedic department's standard thromboprophylaxis involved a first dose of 5000 units of dalteparin given subcutaneously at 6 hours after surgery.

Data was collected on estimated intra-operative blood loss, measured changes in haemoglobin (Hb) levels, and whether a post-operative transfusion was required. Estimated blood loss is classified within our institution as minimal, under 100 ml, under 250 ml, between 250 to 500 ml, between 500 to 750 ml, and over 750 ml. It is calculated from the quantity of blood accumulated in the suction catheters (minus wash used), the weight of blood soaked surgical swabs, and a view of how blood stained the surgical drapes are. It is a consensus estimation involving the surgeon, the anaesthetist and the scrub nurse and is recorded on the anaesthetic chart. Pre and post-operative haemoglobin (Hb) levels were retrieved from the pathology results electronic database within our institution (Patient Manager). These blood samples were taken at the pre-operative assessment and 24-48 hours postsurgery respectively. The difference between the two values of Hb indicates the actual blood loss for the peri-operative period.

Data analysis was performed using the IBM SPSS statistics software for Windows, version 23. All

continuous variables were assessed for normality by observing the skewness, kurtosis and boxplot as well as utilising the Shapiro-Wilk and Kolmogorov-Smirnov tests. Differences in continuous variables were compared using the Mann-Whitney U test (non-parametric data) and the two-sample t-test (parametric data). The Pearson chi-squared was employed to assess the relationship between categorical data. A post hoc analysis was also performed for the primary outcome (estimated blood loss) adjusting the p-value according to the Bonferroni method. Values of $p < 0.05$ were considered statistically significant.

RESULTS

Our final analysis included 198 patients who had undergone total knee replacement. Baseline characteristics of the participants are presented in Table 1. Continuous variables are presented as mean±standard deviation (SD) or median (interquartile range, IQR) based on whether a normal distribution was observed. Categorical variables are shown as percentages (Table 1).

Upon comparison of the two cohorts with regard to baseline characteristics, no significant differences were noted. The majority of the patients underwent operations without the use of a tourniquet (73.7%) and in both groups females outnumbered males. Spinal anaesthesia was more common in both study groups (82.7% and 89% respectively) and no significant difference was observed in the American Society of Anaesthesiologists physical status classification (ASA). Most of the participants were classified as ASA 2, whereas one participant in each

group was characterised as ASA 4. More importantly, no statistical difference was detected in the percentage of patients receiving anticoagulants or antiplatelets; therefore minimising potential confounding factors. Most of the participants were receiving aspirin, while almost a quarter were using clopidogrel.

Estimated blood loss and data related to other surgical parameters are presented in Table 2. Upon comparison of the estimated blood loss between the two cohorts, statistical significance was noted ($p < 0.001$), hence a post hoc analysis was performed utilising the Bonferroni correction (adjusted p-value, $p=0.0062$). Participants in the tourniquet group had less intra-operative blood loss, since almost half of them experienced minimal blood loss ($p < 0.0001$). On the contrary, most of the patients in the non-tourniquet group (49.3%) were classified as having blood loss between 250-500 ml ($p=0.00014$).

The pre- and post-operative Hb levels were comparable among the groups. A slightly higher Hb level was evident pre-operatively in the non-tourniquet group (132.33 ± 12.8 vs. 128.31 ± 13.82), however this was not deemed statistically significant ($p=0.058$).

Transfusion requirements were also similar among the groups (4.8% vs. 5.8%) and no tendency was suggested towards an increased rate of transfusion in the non-tourniquet group.

Finally the analysis of the Hb drop (g/dl) after surgery, revealed that the use of a tourniquet had no significant effect ($p=0.342$) (Table 2).

Table 1: Characteristics of patients undergoing total knee replacement.

Characteristics	Tourniquet (N=52, 26.3%)	No tourniquet (N=146, 73.7%)	P value
Sex [number of cases, relative frequency (%)]	Male	17 (32.7)	0.839*
	Female	35 (67.3)	
Anesthesia [number of cases, relative frequency (%)]	Spinal	43 (82.7)	0.237*
	General	9 (17.3)	
Age, years, Mean±SD, median (interquartile range)	69.78±9.84	73 (13.25)	0.093 [†]
ASA [number of cases, relative frequency (%)]			
1	1 (1.9)	5 (3.4)	0.683*
2	37 (71.2)	114 (78.1)	
3	13 (25)	26 (17.8)	
4	1 (1.9)	1 (0.7)	
5	0 (0)	0	
Medications [number of cases, relative frequency (%)]			
Aspirin	33 (63.45)	98 (67.1)	0.424*
Clopidogrel	13 (25)	40 (27.4)	
Warfarin	2 (3.85)	2 (1.4)	
NOAC	2 (3.85)	1 (0.7)	
Other	2 (3.85)	5 (3.4)	

[†]Mann-Whitney U test, * Pearson chi-squared test; ASA: American Society of Anaesthesiologists physical status classification; NOAC: novel oral anticoagulant.

Table 2: Estimated blood loss and other surgical parameters in patients undergoing total knee arthroplasty.

Outcomes	Tourniquet (N=52, 26.3%)	No tourniquet (N=146, 73.7%)	P value
Estimated blood loss (milliliters) [number of cases, relative frequency (%)]			
Minimal	25 (48.1)	22 (15.1)	<0.0001 [#]
<250	16 (30.8)	49 (33.6)	0.689
250-500	10 (19.2)	72 (49.3)	0.00014
500-750	1 (1.9)	3 (2.1)	0.92
Haemoglobin drop (g/dl)	23.9±8.92	25.3±9.13	0.342*
Haemoglobin, pre-operative levels (g/dl)	128.31±13.82	132.33±12.8	0.058*
Haemoglobin, post-operative levels (g/dl)	104.4±12.54	107.03±12.53	0.196*
Transfusion [number of cases, relative frequency (%)]	3 (5.8)	7 (4.8)	0.783*

Legend= *two sample t-test, [#] Pearson chi-squared test, adjusted p-value (Bonferroni method, p=0.0062).

DISCUSSION

Our results indicate that more intra-operative blood loss occurs when a tourniquet is not used for primary TKR, but that overall blood loss (calculated by haemoglobin fall) is the same whether a tourniquet is used or not. Furthermore there was no difference in the transfusion rates between the two cohorts.

These findings are in keeping with recent meta-analyses.^{3,6} Our equivalent blood loss finding is further supported by a number of studies, including studies comparing short and long duration tourniquet use.²⁴⁻²⁹ For this to occur post-operative blood loss must be greater when a tourniquet is used. The underlying mechanism as to why this is the case is still not fully understood, though a number of explanations have been postulated. Larsson et al. noted back in the 1970's that when a tourniquet is released there is an increased reactive blood flow to the limb.³⁰ This effect was found to peak 5 minutes after tourniquet release, though persisted for several hours. Wakankar et al reported that this reactive hyperaemia can contribute to limb swelling and increased soft tissue tension after a tourniquet release, which in turn may explain the increased wound pain that this group of patients feel.³¹ Limb ischaemia associated with tourniquet use may initiate an increase in fibrinolytic activity, which in turn causes increased bleeding.³²⁻³⁶

The evolution of reducing tourniquet use in TKR has coincided with other techniques to control blood loss being developed. Our results must be taken in the context of the standardised procedures to control blood loss performed in our unit detailed in the methods section. Comparison with earlier studies may not be valid given that these techniques may have evolved over time. It may be that these have tipped the balance in terms of blood loss in the operative field that means not using a tourniquet is possible. It must also be noted that our measurement of intra-operative blood loss is based on a series of somewhat subjective estimations, and is therefore open to inaccuracies. Other articles also describe measuring intra-operative blood loss based on the increased weight of the gauzes used and measuring

the volume of blood aspirated.^{2,4} These inevitable estimates are likely to be the best achievable.

Using a tourniquet for TKR does confer some benefits in the form of decreased operative time, although this was not specifically examined by our study.^{3,37,38} It may be that there is a learning curve to working without a tourniquet, and the average operative time may decrease in time as more surgeons transition over to performing TKR without a tourniquet. This is an area where further research can be carried out in the future. Another quoted benefit to using a tourniquet is that better cementing technique is enabled by improved cement penetration into bone.^{4,3,37} However, recent studies have refuted these claims. A randomised controlled trial by Ledin et al, demonstrated no difference using radiostereometric X-ray analysis at two years for implant migration.²⁰ Vertullo et al evaluated radiographic evidence for cement penetration in the immediate post-operative period.³⁹ They also found no significant difference between the tourniquet and no tourniquet groups. Although it is beyond the scope of this study to expand upon the numerous complications associated with the use of a tourniquet, they are worth briefly mentioning. There are reports of increased risk of thromboembolism, and of cardiac, pulmonary and cerebral microemboli.⁴⁰⁻⁴⁵ There are also reports of nerve injury, and issues of the tourniquet induced ischaemia possibly influencing wound healing.⁴⁶⁻⁴⁹

CONCLUSION

Our study, in keeping with other reports within the literature, shows that although estimated intra-operative blood loss is increased without a tourniquet, total blood loss as measured by haemoglobin levels is no different for primary TKRs that use a tourniquet and those that do not. Furthermore the post-operative blood transfusion rates are not significantly different between the two groups. Given that there is recent evidence within the literature that tourniquets do not improve cement technique, and that a number of reported complications are associated with the use of a tourniquet, it is our hope that this study will add to the body of evidence for surgeons to consider no longer using a tourniquet for primary TKR.

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