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Reduced length of stay and faster recovery after total knee arthroplasty without the use of tourniquet

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ABSTRACT

Introduction: Total knee arthroplasty (TKA) is commonly performed using tourniquet despite being associated with several recognised complications that may affect patient's post-operative recovery and early rehabilitation. In this study we investigate whether or not use of a tourniquet during TKA was associated with shorter length of stay, faster recovery and lesser complications.

Methods: 29 patients, who underwent bilateral sequential TKA, had their first TKA under tourniquet and the second TKA 15 (11–32) months later without tourniquet.

All operations were performed by the first author using the same technique and instrumentation with the same early rehabilitation protocol. All patients were followed prospectively for a minimum of 8 months.

All patients had the following parameters measured which included surgical time, length of stay, post-operative pain using Visual analogue score (VAS), calf circumference, drop in haemoglobin, haematocrit level, oxford knee score (OKS), and range of motion (ROM).

Results: TKA performed without the use of tourniquet had significantly shorter Length of hospital stay (3.6 vs 4.4, $P < 0.05$), significantly less pain on day 2 (1 vs 2; $P < 0.05$) and significantly smaller increase in calf circumference on day 2 (1.2 cm vs 2.3 cm; $P < 0.05$). Postoperative calf circumference increase of less than 2 cm in TKA without tourniquet was associated with shorter length of stay when compared with increase of more than 2 cm in TKA with tourniquet 2.9 days (SD 0.6) versus 3.9 days (SD 0.8) $P < 0.05$. ROM and OKS were significantly better in TKA without tourniquet at 6 weeks but no difference at 8 months.

Conclusions: TKA done without tourniquet was associated with shorter length of stay, lesser pain and swelling, in addition to improved range of motion in the early post-operative period

1. Introduction

Tourniquets are frequently applied in total knee arthroplasty (TKA) to ensure less intraoperative bleeding and create a bloodless surgical field, thereby potentially reducing surgical time, improving the quality of cementation, and ensuring long-term fixation Bannister and Miles 1988,[1] Rama et al.2008,[2] smith and Hing 2010,[3] Tsarouhas et al.2012.[4]

However, there are disadvantages when using a tourniquet, including thigh pain, nerve palsy, ischemia, soft tissue damage, thromboembolic complications, poor wound healing, and patella mal-tracking. Komatsu et al.2003,[5] Smith and Hing 2010,[3] Tai et al. 2011.[6]

Furthermore, recovery may be delayed due to reduced muscle strength, reduced knee ROM, and increased pain, Saunders et al. 1979.[7] Other studies have shown increased pain and impaired ROM up to 1 year after surgery in which a tourniquet was used, Abdel-Salam and Eyres 1995,[8] Ledin et al. 2012.[9]

Several randomised controlled trials and meta-analyses dealing with adverse effects of tourniquet use have been published but disagreement still remains as to whether TKA surgery should be performed with or without the use of a tourniquet, Smith and Hing 2010,[3] Tai et al. 2011,[6] Alcelik et al. 2012.[10]

In this study we examined the effects of tourniquet use on length of hospital stay, post-operative leg swelling, pain and analgesic consumption as primary outcome.

We hypnotized that the absence of a tourniquet during TKA

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would improve functional outcomes and reduce length of hospital stay.

Functional outcome OKS, knee ROM, drop in Haemoglobin and haematocrit levels 48 h post-operatively, surgical time, surgical visibility and difficulties, and transfusion requirements were recorded as secondary outcome.

2. Patients and methods

This prospective study included 29 patients who had bilateral sequential knee replacement between January 2014 and December 2016 with age range of 58–81 years (mean 73), mean BMI 33 (28–42), All patients had the same early rehabilitation protocol for both knees but their first knee was done under tourniquet control and the second knee replacement without tourniquet. The mean time difference between two knees was 15 (11–32) months.

The inclusion criteria consisted of patients who underwent initial unilateral TKA under tourniquet for osteoarthritis or rheumatoid arthritis. Exclusion criteria were patients who had general anaesthesia or nerve block instead of spinal anaesthesia, second sequential TKR performed by a different surgeon, history of infection after first TKR, coagulation disorder.

Early rehabilitation protocol consisted of patient education in joint school about 6 weeks before surgery. Patients had their surgery under spinal anaesthesia using heavy Marcaine with Diamorphine (300-500mcg). In addition they had peri-articular local infiltration of 30 ml 0.5% Chirocaine, 1 ml 1:1000 Adrenaline and 30 mg Ketorolac mixed with 100 ml Normal Saline and 1 gm of Tranexamic acid intravenous immediately before the skin incision was made. Thrombosis prophylaxis was achieved with enoxaparin 40 mg subcutaneously for 2 weeks and TED stockings for 6 weeks postoperatively.

The tourniquet was inflated to 300 mmHg after limb exsanguination and released after skin closure.

Surgery was performed by the first author. A midline skin incision with medial Para-patellar approach was used. An intramedullary guide system was used in the femur and extra-medullary guide for the tibia. Intra-operative local infiltration containing Adrenaline, Chirocaine and Ketorolac was administered in both groups. This was followed by high pressure pulse lavage and swab packing to remove blood and provide better cement integration in non-tourniquet group. Bone cement with Gentamycin was used during implantation of the tibia and femoral prosthesis in one stage in both groups.

A Cruciate retaining prosthesis (Triathalon, Stryker) was used in all cases. A peripatellar neurectomy was performed routinely using diathermy but patella was not replaced in all knees. No drain was used in all knees.

The mean operation time was 56 (50–69) min for those that had tourniquet and 59 (56–67) min for those without.

Postoperative pain was managed by use of regular Paracetamol, Ibuprofen and Oxycontin. Meanwhile oral Morphine sulphate used for breakthrough pain Table 1.

Postoperatively patients were allowed full weight bearing on the first post-operative day followed by daily functional training under supervision of a physiotherapist till discharge.

Pain was assessed daily using visual analogue score VAS score (0 = no pain, 10 = worst pain) on first, second and third post-operative days. Analgesic need for oral Morphine sulphate for breakthrough pain was also recorded.

Haemoglobin (Hb) and Haematocrit level were recorded pre-operatively and 48 h post-operatively and so were surgical times.

The difference between preoperative and postoperative calf circumference was measured at around one third of distance from knee joint to ankle at 24 h s postoperatively before removal of compression dressings and at 48 h postoperatively after removal of pressure dressings.

Functional and clinical outcomes were evaluated using OKS preoperatively, at 6 weeks and 8 months postoperatively. Knee ROM was measured at 6 weeks and 8 months postoperatively.

This study was approved by our department audit and clinical governance committee.

Continuous variable data that were normally distributed were analysed with Paired student t-test, Mann-Whitney *U* test used when not normally distributed, Chi-squared test to analyse categorical variables.

3. Results

Length of stay was shorter in those that had TKA without tourniquet mean 3.6 days[2–5] in comparison to the tourniquet group mean 4.4 days[3–6] ($P < 0.05$).

Pre-operative mean Oxford knee score (OKS) was 18 for non-tourniquet group and 17 for tourniquet group $P > 0.05$. OKS at 6 weeks in comparison with preoperative OKS shows significant improvement in the non-tourniquet group compared to the tourniquet group OKS 16 (SD 4) versus 10 (SD 6) $P < 0.05$. At 8 months there was no significant difference between the two groups OKS 22 (SD 3) versus 21 (SD 4) $P > 0.05$.

There was better ROM in the non-tourniquet group at 6 weeks 100 (SD 6.6, CI 90–110) vs. tourniquet group 90 (SD 8.7, CI: 85–95). At 8 months, ROM was similar in both groups 106 (SD 9) degrees vs. 108 (SD10) degrees.

The mean post-operative Pain VAS score in the second and third postoperative days was lower in the non-tourniquet group 4.3(SD 0.9) vs. 7.2(SD 1.6) tourniquet group. Oral Morphine sulphate for

Table 1
Postoperative medications.

Drug	Dose/volume	Route	Frequency	Duration
Oxycodone MR (Oxycontin)	10 mg	Oral	BD	48 h s
Morphine sulphate (liquid)	10 mg	Oral	4 hourly for breakthrough pain48 h s	
Paracetamol	1g	Oral	Regularly QDS	No limit
Ibuprofen (if eGFR>60 ml/min)	400 mg	Oral	8 hourly	1 week
Omeprazole (while on NSAIDs)	20 mg	Oral	OD	1 week
Ondansetron	4 mg	IV	8 hourly	3 post op doses
Cyclizine	50 mg	IM/IV/PO	8 hourly	2nd line anti-emetic
Oxygen	2–4 L/min	INH	24 h nasal specs	
Naloxone	200 μg	IV	PRN	If resp rate <8/min and/or reduced GCS
Senna	15 mg	Oral	OD	1 week
Codeine	30–60 mg	Oral	QDS	From cessation of oxycodone regime
Tinzaparin	Check protocol	SC	OD	As per protocol
Crystalloid fluid	1 L	IV	250 ml stat bolus, to treat hypotension on mobilisation	

breakthrough pain used more in tourniquet group mean 4.9 times a day versus mean 2.1 times a day in non-tourniquet group $P < 0.05$. Meanwhile in the first 24 h, postoperative pain VAS score was not significantly different in non-tourniquet group 4.5 (SD0.8) vs 4.7 (SD 0.7) tourniquet group.

Postoperative Hb drop at 48 h postoperatively was statistically significant in non-tourniquet group in comparison with tourniquet group (2.7+-0.8 g/dl versus 2.4+-0.9 g/dl $P < 0.05$), and Haematocrit (8.9+-3% versus 6.6+-4%, $P < 0.05$) no patient required blood transfusion.

Surgical time was similar in the tourniquet group 56 (SD 5.6) vs 59 (SD 4.3) in the non-tourniquet group.

Calf circumference measured preoperatively compared to the first postoperative measurement at 24 h while pressure dressing was still on shows no significant difference between Non-tourniquet and tourniquet group 0.6 (SD 0.3) versus 0.8 (SD 0.2), $P > 0.05$. Second measurements at 48 h post-operatively after removal of pressure dressing and start of flexion exercises shows significant difference between the two groups No tourniquet 1.3 (SD 0.8) versus tourniquet 2.5 (SD 0.7) $P < 0.05$. We found calf circumference increase of less than 2 cm was associated with better pain control and reduced length of stay 2.9 days (SD 0 .6) versus 3.9 days (SD 0.8) $P < 0.05$ Table 2.

We used electrocautery for excision of lateral meniscus and its posterior capsular attachment. We noticed that 6 patients in non-tourniquet group who had their lateral genicular artery still spurting after excision of lateral meniscus required re-cauterization. These patients had post-operative calf circumference increase less than 2 cm, indicating that it could be one of the important sources of continuous postoperative bleeding that leads to knee and calf swelling.

Two patients from the tourniquet group were readmitted via Accident Emergency for suspected Deep vein thrombosis, which was excluded by ultrasonography. No patient was readmitted from non-tourniquet group.

4. Discussion

We find that this study has shown that performing TKA without use of tourniquet had a positive impact on functional recovery of patients and was associated with reduced length of hospital stay, less post-operative calf swelling and less pain.

15 patients (52%) subjectively described early recovery at 6 weeks of their second sequential knee with no-tourniquet as equivalent to the level of recovery of their first knee with tourniquet at 8 months.

The link between postoperative swelling and recovery was mentioned by Bente Holm 2010[11] who found that decreased knee-extension strength after TKA, which decreases functional performance, seems to be caused in part by postoperative knee swelling in the very early postoperative phase. Li B et al. 2009[12] indicated that tourniquet use may promote postoperative hidden blood loss which includes extravasated blood into adjacent soft tissues and knee joint, and prevent patient's participation in early rehabilitation exercises. It is also theorized that tourniquet induced ischemia results in sustained local reactive hyperaemia lasting many hours; this causes increased haemorrhage into adjacent traumatized tissue in the perioperative period. Aglietti P 2000[13]

It is conceivable that the hidden, postsurgical blood loss is less in patients in whom the surgeons have been able to identify and cauterize bleeding vessels. In non-tourniquet group 6 patients (21%) who had lateral genicular artery identified and cauterized after excision of lateral meniscus with electrocautery had calf swelling less than 1 cm, whereas other patients who had postoperative swelling may have had the lateral genicular artery or other sources of postoperative bleed that was masked by the use of tourniquet or low blood pressure in the rest of non-tourniquet group.

We found that pain score in the no tourniquet group was significantly lower than the tourniquet group. Morze CJ 2013[14] stated that postoperative pain is thought to play a major role in patient's satisfaction after TKA. Tai et al. 2012[15] found reduced postoperative pain when a tourniquet was not used, with no difference in ROM.

Tourniquet induced soft tissue damage are still not well described. Tsarouhas et al. 2012[4] measured serum creatine phosphokinase in patients less than 40 years during arthroscopic meniscectomy. They found tourniquet use for less than 30 min was safe with no systemic response. In our group tourniquet time was longer with mean 56 min (SD5.6) which may result in increased serum creatine phosphokinase that may lead to increased pain and greater analgesic requirement than knees operated on without tourniquet. However our results of significant increase in post-operative pain in tourniquet group after 48 h following removal of pressure dressings indicated that it is less likely to be the direct consequence of soft tissue damage and hypoxia caused by the tourniquet, but it could be as a result of the haematoma and swelling.

Our finding of better early functional recovery as shown in Oxford knee scores and better range of motion at 6 weeks in non-tourniquet group are in line with the finding of Zhang W et al., 2014 (16.) In a meta-analysis of 13 randomised clinical trials involving 689 patients; the postoperative range of motion in non-tourniquet group was more than that in tourniquet group during early stages after surgery. Ejaz et al. 2014[17] showed that no tourniquet in TKA results in faster recovery and better range of motion. The mechanism behind the reduced range of motion in tourniquet group is unclear, however, the increased pain may reduce patient's ability to perform postoperative exercises, Liu et al. 2014[18] compared quadriceps function using electromyography following TKA with and without tourniquet use. They found that the tourniquet group had significantly more pain and limited quadriceps function than the non-tourniquet group post-operatively at 6 months.

Our study shows only short term reduction in ROM when using tourniquet which could be explained by comparatively more swelling and pain in the early post-operative period, in contrast Ledin et al. 2012[9] found that when tourniquet had been used knee ROM was still reduced at 2 years, Vandenbussche et al. 2002[19] and Li et al. 2009[12] had the same finding.

There was a mild Hb drop postoperatively in knees without tourniquet in comparison with knees with tourniquet. The drop was not clinically significant as no patient from either group needed a transfusion. This is the same conclusion in meta-analysis by Smith and Hing 2010[3] and Tai et al. 2011[6]

Two patients who had TKA with tourniquet were readmitted to

Table 2
Summary of clinical results.

	Tourniquet	No Tourniquet	P value
Length of Hospital stay	3.6 days	4.4 days	$P < 0.05$
OKS (preoperative) 17	18	$P > 0.05$	
OKS improvement at 6 weeks	10	16	$P < 0.05$
OKS improvement at 8 months	21	22	$P > 0.05$
ROM at 6 weeks	90	10	$P > 0.05$
ROM at 8 months	106	108	$P > 0.05$
VAS 24 h	4.7	4.5	$P > 0.05$
VAS 48–72 h	7.2	4.3	$P < 0.05$
Morphine sulphate frequency 48 h	4.9	2.1	$P < 0.05$
Hb drop post-op	2.4 g/dl	2.7 g/dl	$P < 0.05$
Haematocrit drop post-op	6.6	8.9	$P < 0.05$
Surgical operative time	56 min	59 min	$P > 0.05$
Calf circumference at 24 h	0.6 cm	0.8 cm	$P > 0.05$
Calf circumference at 48 h	2.5 cm	1.3 cm	$P < 0.05$

emergency department because of significant calf swelling. Investigation showed no evidence of Deep vein thrombosis. Meta-analysis of clinical studies on the perioperative tourniquet use in TKA showed that although tourniquet use saves time, it increases thromboembolic complications and doesn't significantly reduce blood loss. The long term outcome of tourniquet use is uncertain. Alcelik I 2012,[10] Jiang FZ 2015,[20] Tia Tw 2011,[6] Yi S 2014,[21] Zhang W 2014[16]

Intraoperative visibility and cement penetration remains an issue when not using a tourniquet. However, in two randomized controlled trials, Ledin et al. 2012,[9] Molt et al. 2014[22] implant fixation was investigated using radio-stereometric analysis to assess the effect of a tourniquet on fixation during cemented TKA. Both studies showed that a tourniquet did not improve fixation of the implant when compared with no tourniquet. We used maximum knee flexion in addition to pulse lavage and swab packing to obtain a dry cutting bone surface for proper bone cementing. We notice that low blood pressure helps in obtaining dry surface, however this should be balanced against the disadvantage of making identification of bleeding sources like lateral genicular artery more difficult.

In our study operation time was similar in knees with or without tourniquet. Although tourniquet use could facilitate a dry bone surface and decrease preparation time for cement fixation of implants, we found that maximum knee flexion and high-pressure pulse lavage facilitated a good dry bone surface in non-tourniquet knees. The same was found by Ejaz et al. 2014,[17] Vandenbussche et al.2002.[19]

OLivecrona C 2013[23] has suggested that tourniquet use at a lower pressure eliminates the risks associated with high pressure tourniquet. A similar finding was noticed with the use of tourniquet for a limited time by Zhang W 2014[16] in a meta-analysis. We can't comment on those studies as our tourniquet pressure was 300mmhg and was released only after wound closure.

The limitation of this study was a small sample. Tourniquet was used until wound closure, so we cannot comment on tourniquet release before wound closure or on low pressure tourniquet. The strengths of this study are that we were able to demonstrate this in the same patient who had both knees replaced in a by the same surgeon in a sequential manner with a an average time between procedures of about 15 months.

5. Conclusions

The findings of reduced length of hospital stay in patients who had TKA with no tourniquet in comparison with TKA with tourniquet seems to be caused in part by post-operative knee swelling in the early postoperative phase. Future studies may seek to identify the location and main source of bleed that leads to post-operative swelling and to design specific interventions aimed at decreasing the degree of knee swelling after TKA.

Conflicts of interest

Serajdin Ajnin and Richard Fernandes certify that they have no financial conflict of interest (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) in connection with this article.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jcot.2019.08.016.

References

1. Bannister GC, Miles AW. The influence of cementing technique and blood on the strength of the bone-cement interface. *Eng Med*. 1988;17(3):131–133.
2. Rama KR, Apsingi S, Poovali S, Jetti A. Timing of tourniquet release in knee arthroplasty. Meta-analysis of randomized controlled trials. *J Bone Jt Surg*. 2007;89(4):699–705.
3. Smith TO, Hing CB. Is a tourniquet beneficial in total knee replacement surgery? A meta-analysis and systematic review. *The Knee*. 2010;17(2):141–147.
4. Tsarouhas A, Hantes ME, Tsougias G, Dailiana Z, Malizos KN. Tourniquet use does not affect rehabilitation, return to activities, and muscle damage after arthroscopic meniscectomy: a prospective randomized clinical study. *Arthroscopy*. 2012;28(12):1812–1818.
5. Komatsu T, Ishibashi Y, Otsuka H, Nagao A, Toh S. The effect of surgical approaches and tourniquet application on patellofemoral tracking in total knee arthroplasty. *J Arthroplast*. 2003;18(3):308–312.
6. Tai TW, Lin CJ, Jou IM, Chang CW, Lai KA, Yang CY. Tourniquet use in total knee arthroplasty: a meta-analysis. *Knee Surg Sport Traumatol Arthrosc*. 2011;19(7):1121–1130.
7. Saunders KC, Louis DL, Weingarden SI, Waylonis GW. Effect of tourniquet time on postoperative quadriceps function. *Clin Orthop*. 1979;(143):194–199.
8. Abdel-Salam A, Eyres KS. Effects of tourniquet during total knee arthroplasty. A prospective randomised study. *J Bone Jt Surg*. 1995;77(2):250–253.
9. Ledin H, Aspenberg P, Good L. Tourniquet use in total knee replacement does not improve fixation, but appears to reduce final range of motion. *Acta Orthop*. 2012;83(5):499–503.
10. Alcelik I, Pollock RD, Sukeik M, Bettany-Saltikov J, Armstrong PM, Fismer P. A comparison of outcomes with and without a tourniquet in total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. *J Arthroplast*. 2012;27:331–340.
11. Holm B1, Kristensen MT, Bencke J, Husted H, Kehlet H, Bandholm T. Loss of knee-extension strength is related to knee swelling after total knee arthroplasty. *Arch Phys Med Rehabil*. 2010;91(11):1770–1776. https://doi.org/10.1016/j.apmr.2010.07.229. Nov.
12. Li B, Wen Y, Wu H, Qian Q, Lin X, Zhao H. The effect of tourniquet use on hidden blood loss in total knee arthroplasty. *Int Orthop*. 2009;33(5):1263–1268.
13. Aglietti P, Baldini A, Vena LM, Abbate R, Fedi S, Falciani M. Effect of tourniquet use on activation of coagulation in total knee replacement. *Clin Orthop Relat Res*. 2000;(371):169–177. Feb.
14. Morze CJ, Johnson NR, Williams G, Moroney M, Lamberton T, McAuliffe M. Knee pain during the first three months after unilateral total knee arthroplasty: a multi-centre Prospective cohort study. *J Arthroplast*. 2013;28(9):1565–1570.
15. Tai TW, Chang CW, Lai KA, Lin CJ, Yang CY. Effects of tourniquet use on blood loss and soft-tissue damage in total knee arthroplasty: a randomized controlled trial. *J Bone Jt Surg*. 2012;94(24):2209–2215.
16. Zhang W, Liu A, Hu D, Tan Y, Al-Aidaros M, Pan Z. Effects of the timing of tourniquet release in cemented total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. *J Orthop Surg Res*. 2014;9,125.
17. Ejaz A, Laursen AC, Kappel A, et al. Faster recovery without the use of a tourniquet in total knee arthroplasty. *Acta Orthop*. 2014;85(4):422–426. Aug.
18. Liu D, Graham D, Gillies K, Gillies RM. Effects of tourniquet use on quadriceps function and pain in total knee arthroplasty. *Knee Surg Relat Res*. 2014;26(4):207–213. https://doi.org/10.5792/ksrr.2014.26.4.207. Dec.
19. Vandenbussche E, Duranthon LD, Couturier M, Pidhorz L, Augereau B. The effect of tourniquet use in total knee arthroplasty. *Int Orthop*. 2002;26(5):306–309.
20. Jiang FZ, Zhong HM, Hong YC, Zhao GF. Use of a tourniquet in total knee arthroplasty: a systematic review and meta-analysis of randomized controlled trials. *J Orthop Sci*. 2015;20:110–123.
21. Yi S, Tan J, Chen C, Chen H, Huang W. The use of pneumatic tourniquet in total knee arthroplasty: a meta-analysis. *Arch Orthop Trauma Surg*. 2014;134:1469–1476.
22. Molt M, Harsten A, Toksvig-Larsen S. The effect of tourniquet use on fixation quality in cemented total knee arthroplasty a prospective randomized clinical controlled RSA trial. *The Knee*. 2014;21(2):396–401.
23. Olivecrona C, Blomfeldt R, Ponzer S, Stanford BR, Nilsson BY. Tourniquet cuff pressure and nerve injury in knee arthroplasty in a bloodless field: a neurophysiological study. *Acta Orthop*. 2013;84(2):159–164.