Does Limited Tourniquet Usage in Primary Total Knee Arthroplasty Result in Better Functional Outcomes?

Dear Editor,

Pneumatic tourniquet use has gained popularity in peripheral limb operations since its advent in 1904 by Harvey Cushing, permitting tourniquet pressure to be monitored and manually controlled throughout surgery. In total knee arthroplasty (TKA), application of a mid-thigh pneumatic tourniquet offers the possible benefits of providing a dry operating field, reducing intraoperative blood loss, allowing cement to set in an optimal and completely dry environment thus potentially improving bone-cement inter-digitation and reducing operative time.[1-4]

There is ongoing controversy with regard to risks associated with tourniquet use in TKA surgery.[2,5-10] Many authors have advocated that tourniquet usage compromises the ability to perform early straight-leg-raise and knee flexion after surgery, increases risks of nerve, muscle and vascular injury, as well as postoperative swelling, stiffness and pain.[5,11-13] Cardiorespiratory function may be affected by tourniquet inflation and deflation, which could lead to intraoperative hypoxia, pulmonary embolic events and cardiac arrest.[9] Reactive hyperaemia has also been noted on tourniquet deflation, which may cause substantial bleeding and affect operation time.[2,8,10] Tourniquets may also be related to an increased incidence of early infection and wound healing disorders due to perioperative hypoxia and reduced postoperative tissue perfusion.[5,7,8] Several authors have correlated tourniquet use and an increased incidence of venous thromboembolic phenomena. [6,7,8]

Arthroplasty surgeons continue to face a dilemma on the ideal time of tourniquet release. The relationship between duration of tourniquet use and development of postoperative complications also remains controversial. This has resulted in variations in the profile of tourniquet use; either throughout the procedure, use for part of the procedure, or none at all. There have been few prospective studies evaluating clinical outcomes of partial or limited tourniquet use in TKA surgery. There is scant literature on the effects of cement inter-digitation, or long-term outcomes of implant loosening or radiolucency between patients who received conventional tourniquet compared to limited tourniquet and non-tourniquet assisted TKA surgery. The aim of this study is to determine whether the limited use of a tourniquet during TKA surgery affects predefined clinical outcomes.

Materials and Methods

We reviewed 121 cases of TKA performed by single surgeon (senior author) over a 4-year period between 2005 to 2008 and had been prospectively entered into a database. Using preliminary data, we calculated that our group sizes are adequately powered to detect an effect size of 0.4 at 80% power. All operations were done for osteoarthritis. Only unilateral surgeries were performed. Patients with inflammatory arthritis on potential procoagulant medications were excluded. There were no anticoagulated patients in this cohort. The first 68 patients underwent surgery with limited tourniquet use and the subsequent 53 patients underwent surgery with conventional tourniquet use. Tourniquets used were automatic pneumatic tourniquets and pressures were standardised at 300 mmHg. We defined "limited tourniquet use" as deflation of tourniquet until cementation of implants and "conventional tourniquet use" as tourniquet use throughout surgery and deflation after wound closure and application of initial dressings. The following data parameters were recorded: age, gender, race, coexisting medical problems, type of anaesthesia, use of tourniquet and tourniquet time, operating time and drain volumes postoperatively. Institutional review board (IRB) approval was obtained for the study and informed consent was taken from all patients.

The 2 groups were well-matched in terms of age, gender, ethnicity, comorbidities, use of aspirin, type of anaesthesia, and preoperative range-of-motion. Postoperative incidence of deep vein thrombosis (DVT) was evaluated. Preoperative and postoperative pain scores using the visual analogue scale (VAS), joint range-of-motion, and radiographic evidence of implant loosening, were assessed over a period of 2 years postoperatively.

Surgical Technique and Postoperative Rehabilitation

A longitudinal midline incision and medial parapatellar arthrotomy was performed in all operations. The prostheses used were all cemented implants (Scorpio NRG, Stryker, Mawah, New Jersey). All knee prostheses were posterior-stabilised and the patella was not resurfaced. With reference to tourniquet use, there were 2 subsets of patients namely Group A (conventional tourniquet), who had the tourniquet inflated until cementation of the implants, wound closure and

Table 1. Summary of Patient Cohort

Characteristics	Group A: Tourniquet Up Throughout Surgery (n = 53)	Group B: Tourniquet Deflated After Cementation (n = 68)
Mean age	66.7 ± 7.08	66.4 ± 7.2
Gender		
Male	14	19
Female	39	49
Race		
Chinese	49 (92.4%)	53 (77.9%)
Indian	2 (3.8%)	8 (11.8%)
Malay	1 (1.9%)	5 (7.4%)
Others	1 (1.9%)	2 (2.9%)
Comorbidities		
Hypertension	43 (81.1%)	51(75%)
Diabetes mellitus	19 (35.8%)	18 (26.4%)
Prior cerebral vascular accident	6 (11.3%)	2 (2.9%)
Taking aspirin	7 (13.2%)	7 (10.3%)
Type of anaesthesia		
General anaesthesia	50 (94.3%)	59 (86.8%)
Regional anaesthesia	3 (5.7%)	9 (13.2%)
Mean operative time (min)	81.6 ± 11.8	97.7 ± 21.9
Mean tourniquet time (min)	84.8 ± 11.2	48.7 ± 12.7
Mean postoperative drain volume (mL, 24 hours after operation)	235.3	224.6

application of initial dressings, and Group B, who had the tourniquet deflated just after cementation of implants (limited tourniquet). In the subgroup with limited tourniquet usage, compression bandaging was performed after implantation of the cemented endoprosthesis (both femoral and tibial components) and the cement was allowed to set with the knee in full extension. The tourniquet was deflated at this point. This adoption of an event-based criterion ensured consistency in defining the use of the tourniquet.

All patients received a single dose of intravenous cefazolin (first-generation cephalosporin) prior to anaesthesia and 2 subsequent doses postoperatively, 8 hours apart. All patients had 1 Radivac drain placed for 24 hours and drainage volumes were charted. All patients were given mechanical calf pumps for DVT prophylaxis. Physiotherapy for ambulation with a walking frame was commenced on postoperative day 1. A routine Doppler ultrasound examination for DVT was performed on postoperative day 5.

Patients were followed up in the outpatient clinic at 2 weeks, 6 weeks, 3 months, 6 months, 1 year and 2 years postoperatively. During the follow-up visits, wound examination was done by the senior author, and range-of-motion measurements were performed using goniometers. Radiographs were taken on postoperative day 1, at 6 weeks postoperatively, 3 months, 6 months, 1 year and 2 years postoperatively.

Statistical Analysis

All data was analysed with the use of SPSS version 18.0. All categorical variables were evaluated by the Fisher's exact test. Continuous variables were evaluated by Student's t-test. The level of significance was established at 95% confidence limits (P <0.05).

Results

There were 88 female and 33 male patients. Of these, 102 were Chinese, 10 were Indians, 6 were Malays and 3 were classified under other ethnic origins. The mean age was 66.5 years. There were 53 patients in Group A (conventional tourniquet use) and 68 patients in Group B (limited tourniquet use). There were no significant differences in age, gender, race, presence of comorbidities and usage of aspirin between the 2 groups.

There was no significant difference in type of anaesthesia, type of implant, and postoperative haemoglobin as well as postoperative drain volumes between the 2 groups. The mean operating time was significantly higher in Group B as compared to Group A (97.7 vs 81.6 minutes, P = 0.00). Table 1 shows the summary of the patient cohort.

There was no significant difference in the postoperative range-of-motion (P = 0.754) between the 2 groups. The improvement in the knee range-of-motion postoperatively in the 2 groups is summarised in Table 2 and Figure 1.

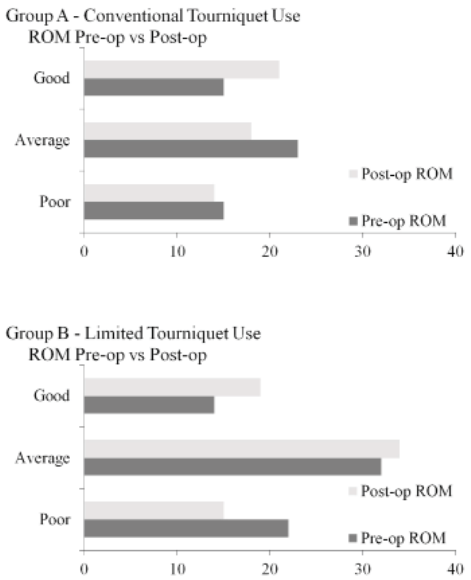

Fig.1. Comparison of range-of-motion among the 2 groups. Poor: <90 degrees; Average: 90-110 degrees; Good: 110 degrees.

Table 2. Knee Range-of-Motion at 2 Year Follow-up

Characteristics	Group A: Tourniquet Up Throughout Surgery (n = 53)	Group B: Tourniquet Deflated After Cementation (n = 68)
Preoperative ROM	97.2° +/- 19.2°	93.0° +/- 22.4°
Postoperative ROM	117.3° +/- 15.2°	116.5° +/- 12.6°
Mean difference	20.1°, 95% CI, (14.8°, 25.4°)	23.5°, 95% CI, (18.2°, 28.8°)
Improvement in ROM in %	25.1%	30.3%

ROM: Range of motion

The most important predictor of postoperative range-of-motion was preoperative range-of-motion. The observation was the same at 2 years follow-up.

There was a significant difference ($P = 0.04$) in the overall (proximal and distal DVT) incidence of postoperative DVT when the tourniquet was used in a limited fashion as compared with conventional tourniquet use. In the subgroup of patients whom tourniquet use was done in the conventional manner, there were 12 cases (23%) of overall postoperative DVT. In the subgroup of patients whom tourniquet use was done in a limited fashion, the incidence of overall postoperative DVT was 9% (6 cases). This difference was statistically significant ($P = 0.04$). However, the incidence of proximal DVT in both groups was similar (5.6% and 4.4%, $P = 0.13$, Fig. 2).

One month after surgery, there were 24 patients (45%) in Group A who reported postoperative pain needing daily painkillers and occasionally limiting rehabilitation, and 18 (26.5%) patients in Group B reported the same. At the 2 year follow-up outpatient review, most patients reported mild or no pain (Fig. 1). Nine (17%) patients in Group A reported postoperative pain, while 6 (8.5%) in Group B reported postoperative pain (Fig. 3). The difference in prevalence of postoperative knee pain at 2 year postoperatively between the 2 groups was statistically significant ($P = 0.03$).

During the follow-up over 2 years, there was no case with radiographic evidence of implant loosening in both groups. We defined a strict criteria for radiographic implant loosening comprising of periprosthetic lucent lines, lucencies and changes in implant position in an attempt to include early and subtle cases of loosening. All radiographs were reviewed by the senior author and a consultant musculoskeletal radiologist.

Of the 121 patients that underwent total knee replacement, none experienced complications such as dislocation, wound infection or dehiscence, nerve or vascular injury and periprosthetic fractures.

Discussion

Limited or no tourniquet use has often been suggested to increase operative time and blood loss. Our approach has been postulated to cause a compromised cementation field and suboptimal implant fixation, affecting the surgical and functional outcomes. In our study, however, we did not encounter any technical difficulties in limited tourniquet use. The complication rate was not increased and the functional outcomes of the patients postoperatively were not affected. Rather, the limited tourniquet subgroup fared better in terms of pain scores at 2 year follow-up and had a lower overall incidence of DVT in the immediate postoperative period.

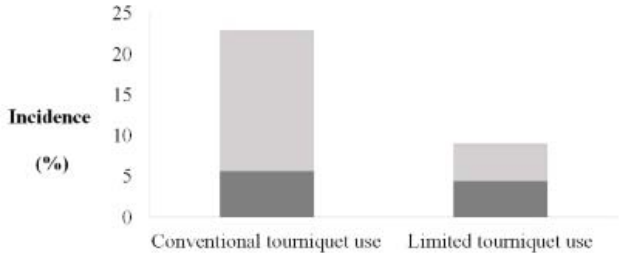

Fig. 2. Incidences of overall and proximal DVT among patients with limited tourniquet use and conventional tourniquet use (dark shaded areas represent incidence of proximal DVT).

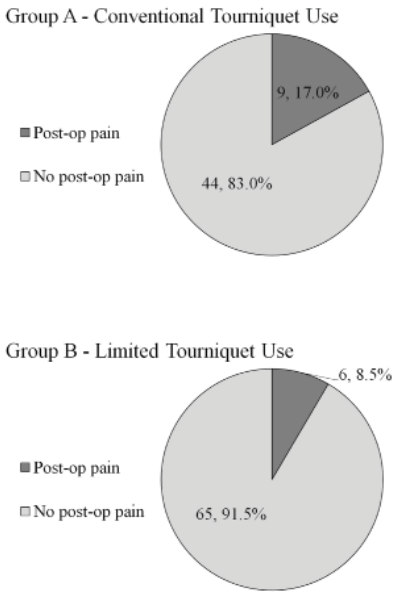

Fig. 3. Comparison of knee pain between patients with conventional and limited tourniquet use at 2 year follow-up.

Over the 2 year follow-up period of the subjects, there was no radiographic evidence of implant loosening which may be attributed to blood at the cement-bone interface leading to compromised cement interdigitation. The cement itself has probably played a hemostatic role on bleeding bone surfaces.[14] It is therefore unlikely that the bone-cement interdigitation process will be compromised in the absence of a tourniquet.

Moreover, patients with limited tourniquet use experienced good surgical and functional results. Our findings were in agreement with Abdel-Salam and Eyres,[7] in which patients with limited tourniquet use experienced less postoperative pain. We attribute the reduction in postoperative knee pain as a result of reduced direct pressure and injury to the nerves and soft tissue from limited tourniquet use.[8]

Limb swelling from reactive hyperemia from tourniquet use could increase the tension of the soft tissue around the knee, hinder knee flexion movement, reduce knee range-of-motion and pain.[5,11-13] In our study, there was no significant difference in postoperative range-of-motion between patients who had undergone surgery with conventional tourniquet usage and those with limited tourniquet usage. With the exclusion of tourniquet during the cementation phase, the knee range-of-motion postoperatively is not significantly affected, disputing the belief by some authors that the process of bone-cement interdigitation would be compromised and leading to worse functional outcomes and knee range-of-motion.

The effect of tourniquet use on blood loss has been reported in several studies. Smith TO and Hing CB,[2] in a meta-analysis of 15 studies, have also found that there is no advantage to using a tourniquet in TKA for the reduction of transfusion requirements or reducing total blood loss. Several publications have also shown that there was no difference in total blood loss and transfusion requirements.[3,10,13-15] Bin Li et al[12] has concluded that postoperative wound blood loss, the hidden blood loss and the calculated total blood loss were significantly greater in tourniquet usage. Although there could be some advantage in reducing intraoperative blood loss with the use of tourniquet, this could be offset by significantly greater overall blood loss as a result of reactive hyperemia.[8] In our study, there were no significant differences in drain volumes between the 2 subgroups.

There is a significant reduction in overall risk of postoperative DVT through limited tourniquet use in TKA, without compromising the postoperative results. The overall incidence of postoperative DVT is significantly lower with limited tourniquet use ($P = 0.04$). Chung et al[16] reported that the incidence of DVT appeared to be increased in patients with a higher tourniquet time but their results did not show statistical significance. We believe that shortening the tourniquet time leads to a lower incidence of DVT by reducing the duration of venous stasis. Eliminating tourniquet usage completely may increase surgical times further thereby placing the patient at higher risk of infection and DVT. Usage of the tourniquet in a limited fashion is a reasonable compromise.

Limitations of our study include the lack of comprehensive assessment of subjective symptoms of pain and it not being a randomised controlled study. It is a prospective cohort study in which the first 68 patients underwent surgery with limited tourniquet use and the subsequent 53 patients underwent surgery with conventional tourniquet use. Moreover, being a single-surgeon study, variability in surgical technique affecting the results has been minimised. The distribution of patients in both groups was even so as to eliminate confounding factors. The relative proportion of regional and general anaesthesia differed slightly between the 2 groups, but this difference was not of statistical significance.

There exists significant controversy in thromboprohylaxis protocols for patients undergoing TKA in the Asian context. Chung et al[16] mention that no often regular prohylaxis is given in Asia, compared to Western countries due to perceived differences in the incidence of venous thrombo-embolic phenomena. The duration of chemical thromboprohylaxis remains controversial.[17,18] In addition, duplex ultrasound may overestimate the incidence of DVT. In our cohort of patients, routine chemical thromboprohylaxis was not administered (in keeping with institutional guidelines at that time). All patients received mechanical calf pumps and patients with above knee DVT received anticoagulation for 6 months. However this is unlikely to affect the results as routine chemoprohylaxis may lower the overall incidence of DVT but the difference in DVT incidence due to duration of tourniquet usage will not be affected as long as the 2 groups remain consistent.

Conclusion

In this study, patients who had undergone TKA with limited tourniquet use had lower overall incidences of postoperative DVT and fared better in terms of postoperative pain at 2 years of follow-up. Clinical outcomes of joint range-of-motion and radiographic evidence of implant loosening were comparable in both groups. The routine use of tourniquet in TKA surgery should probably be re-evaluated.

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