International Journal of Surgery 18 (2015) 123–127

Contents lists available at ScienceDirect

International Journal of Surgery

journal homepage: www.journal-surgery.net

Original research

Tourniquet use during total knee arthroplasty does not offer significant benefit: A retrospective cohort study

Serhat Mutlu [a, *], Olcay Guler [b], Harun Mutlu [c], Ozgur Karaman [a], Tahir Mutlu Duymus [a], Atilla Sancar Parmaksizoglu [c]

[a] Department of Orthopaedics, Kanuni Sultan Suleyman Training and Research Hospital, Atakent Mh., 1. Cd, 34303, Küçükçekmece, Istanbul, Turkey
[b] Department of Orthopaedics, Medipol University Medical School, Atatürk Bulvarı No:27, Unkapanı, 34083, Fatih, Istanbul, Turkey
[c] Department of Orthopaedics, Taksim Training and Research Hospital, Karayollari Mahallesi, Osmanbey Caddesi, No:120, 34255, Gaziosmanpasa, Istanbul, Turkey

HIGHLIGHTS

- Tourniquets are routinely employed during total knee arthroplasty; however, their use remains controversial.
- Thus, the routine use of tourniquets during knee arthroplasty may need to be reconsidered.
- Tourniquet use provided no overall benefit.

ARTICLE INFO

Article history:
Received 7 March 2015
Received in revised form
9 April 2015
Accepted 21 April 2015
Available online 24 April 2015

Keywords:
Blood loss
Knee
Knee replacement surgery
Tourniquet
Total knee arthroplasty

ABSTRACT

Introduction: Tourniquets are routinely employed during total knee arthroplasty; however, their use remains controversial.
Methods: This study investigates the efficacy and safety of this practice. A retrospective analysis of 186 patients was performed to assess benefits and/or risks associated with tourniquet use during knee arthroplasty. Total knee arthroplasty was performed using the Biomet Vanguard® PCL Prosthesis (Biomet, Warsaw, IN, USA). In total, 126 patients who had undergone total knee arthroplasty were included in our final analysis.
Results: Patients with tourniquets had significantly less intraoperative blood loss than patients without ($P < .001$); patients without tourniquets required more blood transfusions ($P = .551$), and had significantly longer surgical times ($P = .011$). However, patients with tourniquets had more postoperative blood loss ($P < .001$), longer hospital stays ($P = .013$), and more frequent complications ($P = .571$). Blood transfusion requirement was significantly associated with complications ($P < .001$).
Conclusions: Tourniquet use provided no overall benefit.
© 2015 IJS Publishing Group Limited. Published by Elsevier Ltd. All rights reserved.

1. Introduction

Total knee arthroplasty (i.e. total knee replacement) is a surgical procedure in which a diseased or damaged knee joint is replaced with an artificial joint. It is routinely performed to relieve the disabling pain associated with severe arthritis when nonsurgical treatment options, such as medical therapy, are insufficient. Although recent advances in surgical materials and techniques have increased the efficacy of the procedure, patients remain concerned about the pain and length of recovery associated with arthroplasty [1,2].

During knee surgery, intraoperative tourniquets are often placed on the upper thigh to reduce blood flow to the extremity. Tourniquets have been proposed to have various benefits (e.g. drier surgical field, improved implant adhesion to bone, and decreased surgical blood loss) that can enhance procedural speed and patient recovery [3,4]. However, the use of these devices has remained controversial for decades [5,6], and several studies have identified a negative relationship between tourniquet use and postoperative pain, swelling, and recovery [7–12]. Additionally, a recent systematic review found that tourniquet use provides no advantage with regard to transfusion requirements [13]. Although total and/or

* Corresponding author.
E-mail address: serhatmutlu@hotmail.com (S. Mutlu).

http://dx.doi.org/10.1016/j.ijsu.2015.04.054
1743-9191/© 2015 IJS Publishing Group Limited. Published by Elsevier Ltd. All rights reserved.

intraoperative blood loss are reportedly reduced by tourniquet use [9,12,14,15], various other studies have failed to observe these purported reductions in blood loss [7,16,17]. Controversy exists regarding the effects of tourniquets on thromboembolic risk [18,22] and operating time [7,9,23].

Based on current conflicting evidence, there is a fundamental need to further investigate the efficacy and safety of tourniquets during arthroplasty. This is highlighted by the fact that randomized clinical trials continue to be performed to assess the effectiveness of knee replacement surgery in the absence of tourniquets [24]. We thus conducted a retrospective analysis of patients to examine the benefits and/or risks associated with the use of tourniquets during total knee arthroplasty. Overall, our findings will contribute to improvements in procedural recommendations for knee replacement surgery.

2. Materials and methods

The present study was a retrospective analysis of 186 patients who had undergone total knee arthroplasty. Patients who met the following criteria were excluded: bilateral replacement surgery, history of bleeding diathesis, revision of previous total knee arthroplasty, or history of peripheral vascular disease. In total, 126 patients who had undergone total knee arthroplasty were included in our final analysis. This study complied with the Declaration of Helsinki and informed consent was provided by all patients.

Total knee arthroplasty was performed using the Biomet Vanguard® PCL Prosthesis (Biomet, Warsaw, IN, USA). The tourniquet was set to 150 mmHg above the patient's systolic blood pressure and was deflated after setting of the bone cement. Electrocautery was subsequently used for hemostasis. In addition, enoxaparin sodium (4000 IU) was delivered for 12 h to 3 weeks postoperatively to prevent thrombosis, and cefazolin sodium was used during the first 24 h for antibiotic prophylaxis.

Continuous variables are presented as means with ranges, whereas categorical data are shown as percentages. All numerical data were submitted to normality testing using the Shapiro–Wilk test. The Mann–Whitney test was used to determine the statistical significance of numerical data, whereas the z-test was used to determine the significance of non-numerical data (e.g. yes/no criteria for complications or transfusions). The Pearson chi-squared test was used to assess the relationship between transfusions and complications. SigmaPlot software was used for all analyses. P values of $< .05$ were considered to indicate statistical significance. Our work is fully compliant with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) criteria.

3. Results

In total, 126 patients who had undergone total knee arthroplasty were included in our final analysis. The characteristics of these patients are presented in Table 1.

Approximately half (48.4%) of these patients had undergone operations with the use of a tourniquet. Upon comparison of these individuals with those who had not had a tourniquet applied, it was found that the patients in both groups had a similar mean age. Although there were slightly more female patients within the tourniquet subset, both groups comprised a majority of female patients. Many patients displayed osteoarthritis, with a higher prevalence in the tourniquet group than in the non-tourniquet group (90.8% *vs.* 85.7%, respectively). Although few patients presented with rheumatoid arthritis, the frequency of this condition was higher in the non-tourniquet group than in the tourniquet group (14.3% *vs.* 9.2%, respectively). Spinal anesthesia was more common than general anesthesia during surgery, with slightly more patients in the tourniquet subset undergoing spinal blockade. In contrast, more patients in the non-tourniquet group were placed under general anesthesia.

Table 1
Characteristics of all patients undergoing total knee arthroplasty.

	With tourniquet (n = 61)	Without tourniquet (n = 65)
Mean age (years)	67.2 (54–80)	65.8 (56–81)
Female (%)	78.1	72.2
Osteoarthritis (%)	93.8	88.9
Rheumatoid arthritis (%)	6.3	11.1
Spinal anesthesia (%)	84.4	80.6
General anesthesia (%)	15.6	19.4

Data related to the knee arthroplasty procedure are presented in Table 2. The tourniquet group had less than half the amount of intraoperative blood loss than that of the non-tourniquet group ($P < .001$). In contrast, postoperative blood loss (i.e. Hemovac drainage) was significantly lower in the non-tourniquet group ($P < .001$). Although the postoperative hematocrit and hemoglobin levels were similar between the two groups, the preoperative levels were significantly higher in the tourniquet group ($P = .009$ and $P < .001$, respectively). Slightly more patients received blood transfusions in the non-tourniquet group than in the tourniquet group (72.2% *vs.* 62.6%, respectively); more than twice the number of patients in the non-tourniquet group than in the tourniquet group required two units of erythrocyte suspension (13.9% *vs.* 6.3%, respectively). However, while these findings suggest a tendency toward increased transfusion requirements in the absence of tourniquets, the differences between the two groups were not statistically significant (Table 2). Surgical time was significantly longer in the non-tourniquet group ($P = .011$), whereas the duration of the hospital stay was significantly shorter ($P = .013$).

The number of surgery-associated complications within the two patient subsets was analyzed. Few adverse events were observed overall, although the tourniquet group had almost twice as many complications as the non-tourniquet group (16.1% *vs.* 8.2%, respectively). However, this difference was not statistically significant **($P =$ n.s.)**. The most common complications seen within the tourniquet subset were superficial infections, which were treated with oral antibiotics. Additionally, one patient in this group developed skin blistering, while another developed a wound hematoma that did not require treatment (see Table 3). In the non-tourniquet group, delayed wound healing was observed in one patient, while other patients developed superficial infections and wound hematomas similar to those in the tourniquet subset. Notably, although not statistically significant, superficial infections were approximately three times more frequent within the tourniquet group than within the non-tourniquet group (9.3% *vs.* 2.8%, respectively; **$P =$ n.s.**).

The association between the requirement for a blood transfusion and the presentation of complications was also analyzed. Patients who required two units of erythrocyte suspension displayed a statistically significant increase in arthroplasty-related complications ($P < .001$).

4. Discussion

The most important finding of the present study was that the routine use of tourniquets during knee arthroplasty may need to be reconsidered. The present retrospective analysis of patients that underwent total knee replacement surgery was performed to examine the benefits and/or risks associated with tourniquet use during surgery. Patients with tourniquet use showed significantly

Table 2
Blood loss and other surgical parameters.

Parameter	With tourniquet (n = 61)	Without tourniquet (n = 65)	P value
Intraoperative blood loss (ml)	118 (90–160)	328 (200–560)	<.001[c]
Postoperative[a] hemovac drainage (ml)	550 (400–670)	398 (280–490)	<.001[c]
Preoperative levels:			
Htc (%)	38 (35–44)	36 (32–41)	.009[c]
Hgb (g/dl)	12.7 (11.2–13.9)	11.9 (10.5–13)	<.001[c]
Postoperative[b] levels:			
Htc (%)	32 (26–38)	31 (28–36)	.225
Hgb (g/dl)	10.3 (8.8–12.3)	9.9 (8.7–12)	.271
Transfusion (% patients):			
None	37.5	27.8	.551
1 U	56.3	58.3	.942
2 U	6.3	13.9	.525
Operative time (min)	67 (56–82)	72 (56–91)	0.011[c]
Hospital stay (days)	4.7 (4–7)	4.2 (3–6)	0.014[c]

Legend: Htc, hematocrit; Hgb, hemoglobin; U, units of erythrocyte suspension.
[a] During 24 h post-surgery.
[b] After 24 h.
[c] Statistically significant.

Table 3
Complications associated with total knee arthroplasty.

Complications	With tourniquet (n = 61)	Without tourniquet (n = 65)	P value
Total (%)	15.6	8.3	.579
Skin blistering (%)	3.1	–	
Superficial infection[a] (%)	9.4	2.8	.524
Delayed wound healing (%)	–	2.8	
Wound hematoma[b] (%)	3.1	2.8	

[a] Treated with oral antibiotics.
[b] No need for treatment.

less intraoperative blood loss than did patients without. In this regard, patients without tourniquets showed a tendency to require more blood transfusions, and their surgical time was significantly longer. Conversely, patients with tourniquets had significantly more postoperative blood loss and longer hospital stays. Moreover, we observed a non-statistically significant increase in the rate of complications among patients with tourniquets. Finally, increased blood transfusion requirements were significantly associated with complications.

Our findings indicate that there was significantly less intraoperative blood loss with than without tourniquet use during knee arthroplasty. This finding is in agreement with several previous reports that have suggested effective reductions in blood loss with tourniquet use [9,12,14,25], although various other studies have failed to observe reductions in total blood loss [7,16,17,26,27]. This apparent discrepancy may have arisen because although tourniquets effectively decrease intraoperative blood loss, postoperative and total blood loss are reportedly unaltered by tourniquet use [28]. In fact, it has been suggested that tourniquets might promote hidden postoperative blood loss [8,26]. Patients with tourniquets in the present study displayed significantly more postoperative blood loss than did those without tourniquets, suggesting that tourniquet use may negatively impact the recovery process.

The results indicated a tendency for patients in the non-tourniquet group to require more blood transfusions, although this finding was not statistically significant. Interestingly, while another investigation reported the opposite result (i.e. tourniquet use increased the need for transfusions), their result also did not reach statistical significance [16]. Thus, the present findings are in accordance with a recent systematic review that reported no significant advantage of tourniquet use with regard to transfusion requirements [13]. Such results have led experts to question the routine use of tourniquets during total knee arthroplasty owing to the lack of benefit for patients [25]. It has even been suggested that knee replacement surgery without a tourniquet might be superior in terms of thromboembolic events [7,18,20,27]; however, this remains controversial [19,21,22,29]. In contrast, tourniquet use may offer distinct advantages such as enhanced cementation of the bone [30]. Taken together, our results are consistent with previous reports that found reduced intraoperative blood loss, increased postoperative blood loss, and similar transfusion requirements associated with the use of tourniquets during total knee arthroplasty.

The present results indicate that operating time was significantly longer for patients without tourniquets, which is consistent with reports that tourniquet use significantly reduces the operation time [23]. However, other previous reports have suggested no significant difference in the surgical duration as related to tourniquet use [7,9,29]. It is possible that discrepancies in operating times could arise based on local surgical practices or distinct patient populations. Considering our data in the context of current evidence, it appears that positive effects on surgical time might represent an advantage that favors the use of tourniquets under some conditions. One study has already suggested a link between prolonged operative times and increased infection rates [31]; nevertheless, the beneficial effect of reduced surgical time on the final patient outcome requires further validation.

A non-statistically significant increase in the complication rate among patients within the tourniquet group was detected, including an enhanced likelihood of superficial infections. Likewise, previous studies have reported a tendency for more complications in patients with tourniquets [13,14,16]. While it has been suggested that there is no significant difference in the incidence of wound complications with and without tourniquet use [29], another study found that tourniquet use might lead to more superficial wound infections [7]. These apparent discrepancies may result from differences in tourniquet implementation. Increasing the tourniquet time may be an independent predictor of wound complications and infection [32,33]. A tourniquet time of >100 min was found to increase the risk of adverse effects [34]. Thus, the tourniquet time may be a crucial factor that must be considered to ensure that complication rates remain low in patients undergoing total knee arthroscopy. In the present study, the amount of time that each patient wore a tourniquet was not recorded; thus, future studies are warranted to more thoroughly investigate this topic.

A statistically important association was noted between the requirement for a transfusion of two units of erythrocyte suspension and procedural complications in this study. Previous studies examining the link between transfusions and complication rates have yielded controversial results. For example, although Friedman, Homering et al. recently reported that inflammation or infection rates were significantly higher after total knee arthroplasty in patients receiving allogeneic blood transfusions compared with patients receiving autologous blood transfusions [35], other studies have suggested that allogeneic transfusions are not significantly predictive of infection [36,37]. A meta-analysis by Chen, Cui et al. indicated no link between transfusion and infection-related complications [38]. Thus, although our results are interesting, more studies are needed to further determine the link between transfusion requirements and specific complication rates. If our findings can be verified, the prediction of transfusion requirements in patients could become a valuable means to avoid complications related to total knee replacement surgery [39].

Although it has been proposed that tourniquet use may lead to various benefits that can reduce procedure duration and enhance patient recovery [3,4], several previous studies have failed to identify advantages associated with tourniquet use. Arthroplasty performed with or without a tourniquet reportedly yielded similar surgical and clinical outcomes in one study [15]. It is even possible that tourniquet use negatively impacts patient results; patients without tourniquets showed small benefits in the early postoperative period in one study [9], and tourniquet use was found to hinder early postoperative rehabilitation exercises in other studies [8,27]. Patients undergoing surgery in the absence of a tourniquet achieved earlier straight-leg raising and knee flexion [7]. Notably, the present study found a significant difference in early rehabilitation results; those without tourniquets were discharged from the hospital earlier. It has also been reported that tourniquet use may have no benefit with regard to prosthesis cementation [11,40].

This study has several limitations. The sample size may have been too small to draw significant conclusions. Nevertheless, considering our data in the context of other recent studies on the use of tourniquets during total knee arthroplasty, the results have contributed to the current understanding of the safety and efficacy of these commonly used devices. The fact that this study was conducted at a single center may have introduced bias, although our patient population was representative of individuals requiring total knee arthroplasty.

5. Conclusion

We conclude that our results are consistent with previous single-center studies that suggested no significant overall benefit associated with tourniquet use during total knee arthroplasty.

Conflict of interests

The authors declare no conflicts of interest with respect to the authorship and/or publication of this article.

Funding

The authors received no financial support for the research and/or authorship of this article.

References

[1] J.M. Wong, W.S. Khan, M. Chimutengwende-Gordon, G.S. Dowd, Recent advances in designs, approaches and materials in total knee replacement: literature review and evidence today, J. Perioper. Pract. 21 (5) (2011) 165–171.
[2] R.T. Trousdale, B.J. McGrory, D.J. Berry, M.W. Becker, W.S. Harmsen, Patients' concerns prior to undergoing total hip and total knee arthroplasty, Mayo Clin. Proc. 74 (10) (1999) 978–982.
[3] J. Parvizi, C. Diaz-Ledezma, Total knee replacement with the use of a tourniquet: more pros than cons, Bone Jt. J. 95 (B-11 Suppl. A) (2013) 133–134.
[4] K.R. Rama, S. Apsingi, S. Poovali, A. Jetti, Timing of tourniquet release in knee arthroplasty. Meta-analysis of randomized, controlled trials, J. Bone Jt. Surg. Am. 89 (4) (2007) 699–705.
[5] L. Klenerman, Is a tourniquet really necessary for knee replacement? J. Bone Jt. Surg. Br. 77 (2) (1995) 174–175.
[6] D.J. Whitehead, S.J. MacDonald, TKA sans tourniquet: let it bleed: opposes, Orthopedics 34 (9) (2011) 497–499.
[7] A. Abdel-Salam, K.S. Eyres, Effects of tourniquet during total knee arthroplasty. A prospective randomised study, J. Bone Jt. Surg. Br. 77 (2) (1995) 250–253.
[8] B. Li, Y. Wen, H. Wu, Q. Qian, X. Lin, H. Zhao, The effect of tourniquet use on hidden blood loss in total knee arthroplasty, Int. Orthop. 33 (5) (2009) 1263–1268.
[9] E. Vandenbussche, L.D. Duranthon, M. Couturier, L. Pidhorz, B. Augereau, The effect of tourniquet use in total knee arthroplasty, Int. Orthop. 26 (5) (2002) 306–309.
[10] R.L. Worland, J. Arredondo, F. Angles, F. Lopez-Jimenez, D.E. Jessup, Thigh pain following tourniquet application in simultaneous bilateral total knee replacement arthroplasty, J. Arthroplast. 12 (8) (1997) 848–852.
[11] H. Ledin, P. Aspenberg, L. Good, Tourniquet use in total knee replacement does not improve fixation, but appears to reduce final range of motion, Acta Orthop. 83 (5) (2012) 499–503.
[12] T.W. Tai, C.W. Chang, K.A. Lai, C.J. Lin, C.Y. Yang, Effects of tourniquet use on blood loss and soft-tissue damage in total knee arthroplasty: a randomized controlled trial, J. Bone Jt. Surg. Am. 94 (24) (2012) 2209–2215.
[13] T.O. Smith, C.B. Hing, Is a tourniquet beneficial in total knee replacement surgery? A meta-analysis and systematic review, Knee 17 (2) (2010) 141–147.
[14] I. Alcelik, R.D. Pollock, M. Sukeik, J. Bettany-Saltikov, P.M. Armstrong, P. Fismer, 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. 27 (3) (2012) 331–340.
[15] D.A. Stroh, A.J. Johnson, M.A. Mont, P.M. Bonutti, Excellent clinical outcomes in total knee arthroplasty performed without a tourniquet, Surg. Technol. Int. XXI (2011) 189–193.
[16] R. Iorio, W.L. Healy, Tourniquet use during total knee arthroplasty did not reduce total blood loss, J. Bone Jt. Surg. Am. 83 (A-8) (2001) 1282.
[17] T.W. Tai, C.J. Lin, I.M. Jou, C.W. Chang, K.A. Lai, C.Y. Yang, Tourniquet use in total knee arthroplasty: a meta-analysis, Knee Surg. Sports Traumatol. Arthrosc. 19 (7) (2011) 1121–1130.
[18] K. Wauke, M. Nagashima, N. Kato, R. Ogawa, S. Yoshino, Comparative study between thromboembolism and total knee arthroplasty with or without tourniquet in rheumatoid arthritis patients, Arch. Orthop. Trauma Surg. 122 (8) (2002) 442–446.
[19] A. Fukuda, M. Hasegawa, K. Kato, D. Shi, A. Sudo, A. Uchida, Effect of tourniquet application on deep vein thrombosis after total knee arthroplasty, Arch. Orthop. Trauma Surg. 127 (8) (2007) 671–675.
[20] J.L. Parmet, J.C. Horrow, A.T. Berman, F. Miller, G. Pharo, L. Collins, The incidence of large venous emboli during total knee arthroplasty without pneumatic tourniquet use, Anesth. Analg. 87 (2) (1998) 439–444.
[21] P. Aglietti, A. Baldini, L.M. Vena, R. Abbate, S. Fedi, M. Falciani, Effect of tourniquet use on activation of coagulation in total knee replacement, Clin. Orthop. Relat. Res. 371 (2000) 169–177.
[22] O. Reikeras, T. Clementsen, Time course of thrombosis and fibrinolysis in total knee arthroplasty with tourniquet application. Local versus systemic activations, J. Thromb. Thrombolysis 28 (4) (2009) 425–428.
[23] A. Yavarikia, G.G. Amjad, K. Davoudpour, The influence of tourniquet use and timing of its release on blood loss in total knee arthroplasty, Pak. J. Biol. Sci. PJBS 13 (5) (2010) 249–252.
[24] R. Lohmann-Jensen, A. Holsgaard-Larsen, C. Emmeluth, S. Overgaard, C. Jensen, The efficacy of tourniquet assisted total knee arthroplasty on patient-reported and performance-based physical function: a randomized controlled trial protocol, BMC Musculoskelet. Disord. 15 (2014) 110.
[25] K.L. Jarolem, D.F. Scott, W.L. Jaffe, K.S. Stein, F.F. Jaffe, T. Atik, A comparison of blood loss and transfusion requirements in total knee arthroplasty with and without arterial tourniquet, Am. J. Orthop. 24 (12) (1995) 906–909.
[26] F.J. Zhang, Y. Xiao, Y.B. Liu, X. Tian, Z.G. Gao, Clinical effects of applying a tourniquet in total knee arthroplasty on blood loss, Chin. Med. J. 123 (21) (2010) 3030–3033.
[27] W. Zhang, N. Li, S. Chen, Y. Tan, M. Al-Aidaros, L. Chen, The effects of a tourniquet used in total knee arthroplasty: a meta-analysis, J. Orthop. Surg. Res. 9 (1) (2014) 13.
[28] X. Li, L. Yin, Z.Y. Chen, L. Zhu, H.L. Wang, W. Chen, G. Yang, Y.Z. Zhang, The effect of tourniquet use in total knee arthroplasty: grading the evidence through an updated meta-analysis of randomized, controlled trials, Eur. J. Orthop. Surg. Traumatol. 24 (6) (2014) 973–986.
[29] H.M. Wakankar, J.E. Nicholl, R. Koka, J.C. D'Arcy, The tourniquet in total knee arthroplasty. A prospective, randomised study, J. Bone Jt. Surg. Br. 81 (1) (1999) 30–33.
[30] R. Tarwala, L.D. Dorr, P.K. Gilbert, Z. Wan, W.T. Long, Tourniquet use during cementation only during total knee arthroplasty: a randomized trial, Clin.

Orthop. Relat. Res. 472 (1) (2014) 169–174.
[31] G. Peersman, R. Laskin, J. Davis, M.G. Peterson, T. Richart, Prolonged operative time correlates with increased infection rate after total knee arthroplasty, HSS J. : Musculoskelet. J. Hosp. Spec. Surg. 2 (1) (2006) 70–72.
[32] C.A. Willis-Owen, A. Konyves, D.K. Martin, Factors affecting the incidence of infection in hip and knee replacement: an analysis of 5277 cases, J. Bone Jt. Surg. Br. 92 (8) (2010) 1128–1133.
[33] K. Carroll, M. Dowsey, P. Choong, T. Peel, Risk factors for superficial wound complications in hip and knee arthroplasty, Clin. Microbiol. Infect. : Off. Publ. Eur. Soc. Clin. Microbiol. Infect. Dis. 20 (2) (2014) 130–135.
[34] C. Olivecrona, L.J. Lapidus, L. Benson, R. Blomfeldt, Tourniquet time affects postoperative complications after knee arthroplasty, Int. Orthop. 37 (5) (2013) 827–832.
[35] R. Friedman, M. Homering, G. Holberg, S.D. Berkowitz, Allogeneic blood transfusions and postoperative infections after total hip or knee arthroplasty, J. Bone Jt. Surg. Am. 96 (4) (2014) 272–278.
[36] M. Basora, A. Pereira, A. Soriano, J.C. Martinez-Pastor, G. Sanchez-Etayo, M. Tio, F. Salazar, Allogeneic blood transfusion does not increase the risk of wound infection in total knee arthroplasty, Vox Sang. 98 (2) (2010) 124–129.
[37] E.T. Newman, T.S. Watters, J.S. Lewis, J.M. Jennings, S.S. Wellman, D.E. Attarian, S.A. Grant, C.L. Green, T.P. Vail, M.P. Bolognesi, Impact of perioperative allogeneic and autologous blood transfusion on acute wound infection following total knee and total hip arthroplasty, J. Bone Jt. Surg. Am. 96 (4) (2014) 279–284.
[38] J. Chen, Y. Cui, X. Li, X. Miao, Z. Wen, Y. Xue, J. Tian, Risk factors for deep infection after total knee arthroplasty: a meta-analysis, Arch. Orthop. Trauma Surg. 133 (5) (2013) 675–687.
[39] I. Ahmed, J.K. Chan, P. Jenkins, I. Brenkel, P. Walmsley, Estimating the transfusion risk following total knee arthroplasty, Orthopedics 35 (10) (2012) 1465–1471.
[40] M. Molt, A. Harsten, S. Toksvig-Larsen, The effect of tourniquet use on fixation quality in cemented total knee arthroplasty a prospective randomized clinical controlled RSA trial, Knee 21 (2) (2014) 396–401.