



Rate of Blood Transfusion in Patients Undergoing Bilateral Simultaneous Total Knee Arthroplasty using Patient-Specific Templates and Conventional Techniques: A Comparative Study

Hafez MA^{1*} and Ghazal P²

¹Department of Orthopaedic, October 6 University, Egypt

²Department of Orthopaedic, Dr Ghazal Clinic for Orthopedic, Jordan

Abstract

Introduction: Blood loss is one of the major concerns for patients undergoing major surgeries such as bilateral simultaneous total knee arthroplasty (TKA). The aim of this study was to determine the rate of blood transfusion in patients undergoing bilateral simultaneous TKA using patient specific templates (PST) and conventional technique.

Materials and Methods: This is a comparative study between 54 patients (108 knees) who underwent bilateral simultaneous TKA using PST in comparison to 63 patients (126 knees) who underwent the same procedure using conventional technique. All procedures were done by one surgeon for each group. Preoperative Hb and the rate of blood transfusion were measured for each group.

Results: The rate of blood transfusion in the PST group was 16.6%, that is, 9 patients required blood transfusion and all were female. The mean preoperative Hb for PST group was 12.39 g/dL (range: 7.8–14.5 g/dL). The rate of blood transfusion in the conventional group was 100%, that is, all patients had blood transfusion. All female patients required additional 1 unit of blood. The mean preoperative Hb for conventional group was 14.5 g/dL (range: 12–17 g/dL).

Conclusion: The rate of blood transfusion in bilateral simultaneous TKA could be reduced when using PST technique in comparison to conventional TKA.

Keywords: Blood loss; Blood transfusion; Bilateral simultaneous TKA; PST; conventional TKA

Introduction

Bilateral simultaneous total knee arthroplasty (TKA) is one of the major surgeries in the field of orthopaedics. It could be associated with blood loss, especially in patients with severe comorbidities or in complex cases that demand prolonged surgical procedures [1]. Surgical techniques have been developing to ensure convenient management of TKA, optimizing the surgical outcome with minimal complications. The surgery aims to eliminating pain, restoring the joint's function and improving the health-related quality of life.

Bilateral simultaneous TKA has been documented to have some technical difficulty and prolonged operative time but more applicability than single TKA due to the shorter rehabilitation period and less complications' rate [2]. However, before taking the decision of performing TKA either unilaterally or bilaterally, it is very important to address the risk factors that patients undergoing TKA may encounter. These risk factors include infection, failure, fracture, cardiovascular or pulmonary complications and blood loss [3].

The rate of blood loss with TKA differs according to the type of surgery (unilateral or bilateral) and the selected protocol for blood management. Also, the type of anesthesia, the anti-inflammatory or antifibrinolytic drug and the technique used for soft tissue manipulation are related to blood loss [4]. Some techniques were proposed to overcome blood loss with TKA such as predonation, blood recovery and hemodilution. However, blood transfusion is meant to be eliminated or prevented as possible to avoid potential complications (e.g., infection) [5].

Several blood-saving strategies have been suggested to reduce the exposure to allogeneic blood

OPEN ACCESS

*Correspondence:

Mahmoud A. Hafez, Department of Orthopaedic, October 6 University, Cairo, Egypt, Tel: +2 010075 66299; E-mail: mhafez@msn.com

Received Date: 28 Jun 2016

Accepted Date: 21 Nov 2016

Published Date: 24 Nov 2016

Citation:

Hafez MA, Ghazal I. Rate of Blood Transfusion in Patients Undergoing Bilateral Simultaneous Total Knee Arthroplasty using Patient-Specific Templates and Conventional Techniques: A Comparative Study. *Remed Open Access*. 2016; 1: 1028.

Copyright © 2016 Hafez MA. This is an open access article distributed under the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Table 1: Percentage of blood transfusion among group 1 in the study population (gender distribution include).

Sex	Number	Blood transfusion	Percentage
Female	45	9	20%
Male	9	0	0%
Combined male/female	54	9	16.6%

and in turn, the transfusion-related complications [6]. Such protocols are based on preoperative and/or intraoperative measures that could reduce the need for transfusion; for example, using tranexamic acid, local infiltration, hemostatic matrix, fibrin sealant and tourniquets [7-9].

Conventional TKA has been applied for decades and is considered the standard technique used in registry data with high success rate [10]. However, computer-assisted arthroplasty has been introduced to offer a minimally invasive surgery using patient-specific templates (PST) based on digital imaging (CT or MRI) [2]. The technique comprises preoperative planning thus the templates can be placed accurately over the distal femur and the proximal tibia following a unique surface matching [11,12].

The aim of the current study is to determine the rate of blood transfusion in 2 cohorts of patients undergoing bilateral simultaneous TKA with conventional technique and PST and to address the rate of blood transfusion for each technique.

Patients and Methods

This is a comparative study on 2 cohorts of patients with advanced arthritis of the knee who underwent bilateral simultaneous TKA. The patients were divided into 2 groups. Group 1 included patients who underwent TKA using PST while group 2 included patients who underwent conventional TKA. Routine blood test was performed for all patients in both groups before and after surgery, preoperative and postoperative Hb levels were documented.

Group 1 consisted of 54 patients (108 consecutive TKA procedures). The female to male ratio was 5:1 (45 female and 9 male). The mean age was 60.3 years (range: 49-83 years). The mean preoperative Hb was 12.39±1.70 g/dL (range: 7.8-14.5 g/dL) and average hospital stay was 4 days.

Inclusion criteria were primary TKA bilaterally due to articular or fixed flexion deformity; while unilateral cases or patients with revision TKA or blood abnormalities were excluded from this study.

All cases were managed by a single surgeon (first author), with

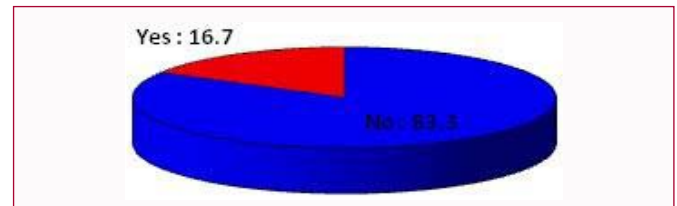


Figure 1: Percentage of the Blood transfusion in group 1.

the patient under a single anesthetic session. The patients received regional anesthesia and were given routine preoperative intravenous antibiotics. All procedures were performed under tourniquet control using conventional medial parapatellar approach and no drains were used. All TKAs were done with PST technique without resorting to intra-medullary or extramedullary alignment guides. No local infiltration techniques or other measures were used for reduction of blood loss. Hemodilution and tranexamic acid (15 gm per Kg) were used routinely.

The indication for blood transfusion for patients with hemoglobin rate was ≤8 g/dL. Also, Thrombex (recombinant thrombex) was used as anti-DVT prophylaxis postoperatively.

Group 2 consisted of 63 patients (126 TKAs). The mean preoperative Hb was 14.5 g/dL (range: 12-17 g/dL).

All cases in Group 2 were managed by a single surgeon (second author) under a single anesthetic session. 2 units of blood were given routinely at the preparation of the second limb. All cases had follow-up for at least three months.

There are 3 methods to determine bleeding: a) Measuring the amount of blood collected by the drains; however, we do not use drains. b) Measuring the pre and postoperative Hb. c) Blood transfusion. We rely on b) and c) in this study.

Results

For group 1, postoperative hemoglobin was found to be 10.40±2.02 g/dL (range: 8.5-12.5 g/dL). Only 9 patients (16.6%) from the whole study population received blood transfusion (Table 1 and Figure 1). All patients who received blood were females with mean preoperative hemoglobin 10.66±1.745 and mean postoperative hemoglobin of 7.93±1.043 (*P* value=0.008) as shown in (Table 2, Figures 2 and 3). Anemia and severe knee deformity were common risk factors for patients who received blood. Other comorbidities in patients who received blood were obesity, hypertension, renal and cardiac diseases.

Table 2: Demography and characteristics of patients who received blood transfusion in group 1.

#	Age	Sex	BMI	Type of deformity	Comorbidities	Preoperative Hb (g/dL)	Amount of transfused blood
1	60	F	30.1	Massive osteophyte	No	9.2	2 unit
2	59	F	33.8	Severe varus	No	9.3	2 unit
3	70	F	29.7	Severe varus	HTN, Cardiac disease	10.7	3 units
4	49	F	29.7	Severe varus	No	8.9	2 units
5	55	F	27.5	Valgus+Flexion deformity 40-50 degree	RA	12	1 unit
6	60	F	34.9	Varus	Severe obesity	12.4	2 units
7	70	F	31.2	Varus	No	8.8	1 unit
8	58	F	26.6	Varus+bone loss	HTN	12	2 units
9	52	F	31.2	Severe varus	No	12.7	1 unit

Bold indicates Hb level less than 10 g/dL with no associated comorbidities.

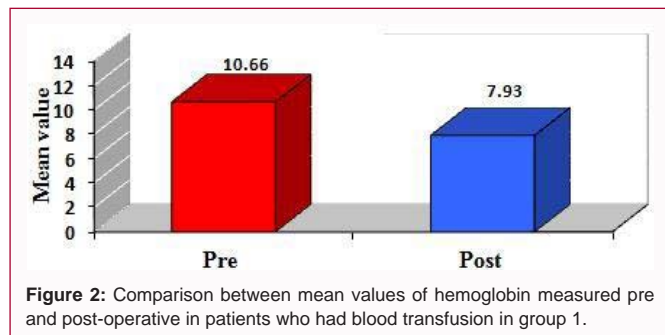


Figure 2: Comparison between mean values of hemoglobin measured pre and post-operative in patients who had blood transfusion in group 1.

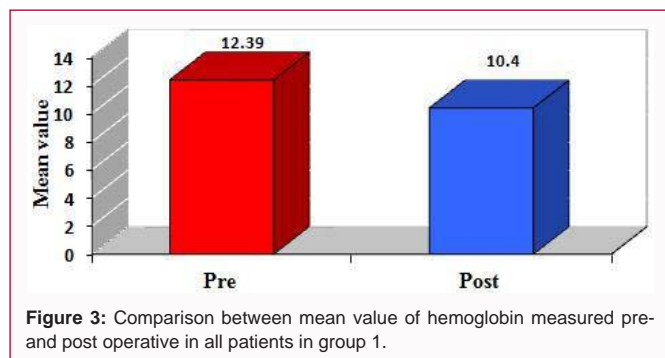


Figure 3: Comparison between mean value of hemoglobin measured pre and post operative in all patients in group 1.

For group 2, 60% of male patients did not need additional blood units, while all female patients required at least 1 additional blood unit (Tables 3 and 4). Only 1 female patient required ICU admission for 12 hours after surgery for unstable blood pressure. Other complications included delayed wound healing due to cortisone therapy for other comorbidities not related to TKA. The ratio of blood transfusion in both groups was 0.16:1 (Figure 4).

Discussion

Blood transfusion with TKA is influenced by surgical technique, operative time, haemostatic measures and patient’s status. Several approaches are suggested in the last years to control blood loss and achieve best surgical outcomes. In literature, it was proven that CAOS techniques eliminate intramedullary perforation that cause higher bleeding [13,14]. PST is a minimally invasive surgery with least injury of muscles and soft tissues thus, it provides shorter recovery period and better limb function with significantly less blood loss [15].

In this study, group 1 The type and degree of articular deformity were assessed ranging from 5–30 varus (average 16.3), 20–40 valgus (average 30), and fixed flexion deformity from 5 to 50 (average 27.5). The arc of motion ranged from 50 to 130 (average 85). All operations were successfully performed using the PST without resorting to conventional instrumentation including medullary guides. However, for educational and verification purposes, the surgeon used the extra-medullary guide of the conventional instrumentation system to double check the position of tibial template on occasional basis. However, femoral and tibial IM guides were never used.

Bilateral simultaneous TKA may be a good option for patients with bilateral knee osteoarthritis; however, concerns about its safety still exist [16]. Data from the Swedish Knee Arthroplasty Register and the Swedish Cause of Death Register revealed some difference in early mortality between patients having simultaneous bilateral TKAs and patients having staged bilateral TKAs [17], in our series no mortalities happened with follow up 5 months to 3 years. Researchers reported that the blood loss associated with TKA could be about 2.2 units per

Table 3: Demographic data of patients in group 2.

Year	No. of Cases	Age	Clinical Diagnosis
2002	3	70–75	Osteoarthritis
2003	2	50–60	Osteoarthritis
2004	2	70	Osteoarthritis
2005	5	60–70	Osteoarthritis
2006	5	50–70	Osteoarthritis
2007	3	55–75	Osteoarthritis
2008	5	60–75	Osteoarthritis
2009	8	50–82	1 case rheumatoid arthritis + 7 cases osteoarthritis
2010	6	60–70	Osteoarthritis
2011	10	60–75	Osteoarthritis
2012	10	55–70	2 cases rheumatoid arthritis + 8 cases osteoarthritis
2013	5	55–75	2 cases rheumatoid arthritis + 3 cases Osteoarthritis

General comorbidities: Hypertension, Diabetes and Obesity.

single TKA due to extensive bone and soft tissue cuts. Therefore, it would be expected that operating on 2 knees rather than 1 knee pre disposes the patient to a greater risk of blood loss and the need for transfusion [18].

To the authors' knowledge, no previous study has been published on bilateral simultaneous TKA using PST with view to the need for blood transfusion. Our study used PST in all cases of bilateral simultaneous TKAs as compared to control group (conventional TKA).

This study has shown that PST significantly reduced blood loss. In fact, the need for blood transfusion cannot be determined by one factor and it could be correlated to other factors, such as preoperative diagnosis, age, deformity severity and postoperative outcome. In theory, PST differs from conventional technique that it eliminates the need for medullary perforation (opening the medullary canal). However, there are other differences that can cause more bleeding such as operative time [19] and the compounding effect of bilateral TKA where the deformity is higher than unilateral, that is increased operative time and compounding factors increase the bleeding tendency.

Controversy exists about blood transfusion with TKA procedures and the measures that could be taken to avoid blood loss. The need for allogenic blood transfusion was found to be associated with high mortality rate and high cost while following appropriate management strategies (e.g., the use of tranexemic acid and plugging of the femoral canal) had some positive impact [20]. The use of fibrin sealant was found to have no effect on drain output or functional recovery with bilateral simultaneous TKA [21]. Literature reviews could not indicate unbiased results regarding transfusion rate and its dependence on the surgeons decision on giving blood preoperatively, immediately postoperatively or delayed and Hb level that which blood transfusion becomes essential. Blood transfusion and blood loss had a reported effect on the overall cost of TKA, hospitalization period and complications rate [22].

Moráis et al. [23] have followed a multimodal blood-loss prevention approach based on Hb, BMI, and American Society of Anesthesiology (ASA) in a study focused on blood transfusion after primary TKA. The authors correlated between these factors to determine the probability of blood transfusion by 70%. Blood

Table 4: Examples of patients given blood routineley in group 2.

No	Sex	Preoperative Hb	Blood units given	Postoperative Hb	Postoperative Hb (2 days)
1	Male	13.4	2	11	11.9
2	Male	14.2	2	13.5	11.8
3	Male	13.9	2	11.5	10.2
4	Male	13	2	12.2	12.1
5	Male	15.1	2	12.1	9.8
6	Female	14.3	2	11.8	11.2
7	Female	12.9	2	13.3	10
8	Female	10.1	2	11.4	11
9	Female	13.2	2	11.8	10
10	Female	10.7	2	8	10
11	Female	10.7	2	9.6	10
12	Female	9.6	2	11.3	10
13	Female	13.7	2	11.6	10

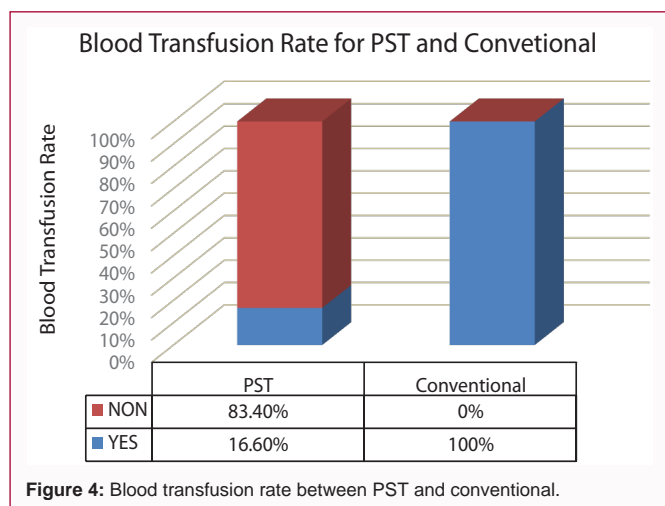


Figure 4: Blood transfusion rate between PST and conventional.

transfusion rate in this study was zero. They also observed that non-obese patients with preoperative Hb<13 g/dL and ASA III were at higher risk of blood transfusion, while those with preoperative Hb<12 g/dL were 5 times of higher risk for blood transfusion than Hb>13 g/dL; finally, patients with Hb between 12 and 13 g/dL had three times higher risk than >13 g/dL. Another study conducted over an unselected group of patients for primary THA and TKA in daily clinical setting had lower risk for blood transfusion compared other literature. However, low preoperative Hb and low BMI are strong determinants for patient receiving blood [24].

In light of navigation TKA, the technique was expected to improve the clinical outcome of the procedure as it reduces the number of outliers and provides enhanced alignment of the mechanical axis; however, the technique was found to be costly with prolonged operating time. Navigation also requires more training, has a high complications rate and has no reproducible evidence in comparison to conventional technique. Both techniques had no difference in Hb drop, transfusion rate or blood loss [25].

Bilateral simultaneous TKAs provide numerous advantages, including decreased total anesthetic period, prolonged rehabilitation time, length of hospital stay and costs. These patients also had lower rates of wound infections and gained a high convenience and satisfaction when compared to staged bilateral TKAs [26,27]. Some

investigators reported that at 10 years follow up the bilateral TKA group had a significantly higher rate of survival than the unilateral TKA group [28].

In this work, patients in group 1 had an average hospital stay of 4 days. Intraoperatively, blood loss could not be measured as we did not use drains. Complications rate was 5% overall. This study demonstrates that the rate of blood transfusion was 16% in simultaneous bilateral TKAs with PST technique. In contrast to the present study, Erin Spicer et al. [29] studied difference of blood transfusion requirement between unilateral and bilateral TKAs and revealed that the needs for transfusion was 29% in bilateral versus 8.9% in unilateral group. A high rate of blood transfusion was documented by Jankiewicz et al. [30] who reported 60% of patients required a homologous blood transfusion in the simultaneous bilateral TKA patients. Also, Lane et al. [27] found that the percentage of blood transfusion was 17 times in bilateral simultaneous TKAs when compared with unilateral TKAs.

A possible explanation of decreased rate of blood transfusion in our study is short operative time and elimination of IM guides which minimize blood loss and make it useful for bilateral simultaneous TKAs [12].

Chareancholvanich et al. [31] found that PST technique has minimal relevant clinical advantage over conventional instrumentation. However, they concluded that PST could slightly shorten the bone-cutting effort and the operative time, without significant difference in postoperative blood loss nor the need for blood transfusion. Both techniques can restore limb alignment and place knee components with the similar accuracy.

Thienpont et al. [32] studied the use of PST in minimally invasive TKA and concluded that no difference between PST and convectional total knee arthroplasty in term of blood loss.

In terms of Hb level, patients with a preoperative Hb of less than 10 g/dL have a 90% chance of transfusion while those with 10 to 13.5 g/dL have 40-60% chance and those with greater than 13.5 g/dL have a chance of 15-25% [33].

In our study, all patients who received blood transfusion had a preoperative Hb less 13.5 g/dL and 4 patients out of 9 patients who received blood transfusion had a preoperative Hb less 9.5 g/dL. Also, patients who required blood transfusion had relatively low Hb

level (mean 10.66 g/dL), which is the strongest predictor of blood transfusion requirement. Moreover, all transfused patients in this series were females.

In Group 2, 60% of male patients did not need additional blood units, while all female patients required at least 1 additional blood unit. However, the incidence of obesity and weak muscles is high in our country, which is an important factor [34].

Other risk factors for blood transfusion are blood volume, weight, age, estimated blood loss, aspirin use and thrombocytopenia [35]. Kreder et al. [36] found that some patients' variables such as age, gender and comorbidity were significant predictors of complications after TKA.

Limitations of this study are that Group 1 was managed at different time period from Group 2, and the two groups were managed by two different surgeons however, both surgeons used the same criteria for blood transfusion. In addition, the mean preoperative Hb of Group 1 was 12.39±1.70 g/dL (range: 7.8-14.5 g/dL) which is less than Group 2 that was 14.5 g/dL (range: 12-17 g/dL) however, Group 1 had cases with severe deformity and this could possibly be the reason of low Hb level, as a result of taking cortisone and analgesics for prolonged time.

In conclusion, computer-assisted PST seemed more suitable for bilateral simultaneous TKA in medically unfit patients and in patients with severe articular deformities. Patients with extra-articular deformities, bleeding tendencies, DVT and/or history of pulmonary embolism are better treated with bilateral simultaneous TKA using PST [37].

Acknowledgement

We are grateful for the fund provided by Miser El Khair foundation (MEK) to sponsor the cost of surgery for some patients in this series. MEK has also supported educational and research activities related to this series. This charitable act is aimed at needy patients who have no medical insurance and no source of funding for surgical intervention.

References

- Ekinci Y, Oner M, Karaman I, Kafadar IH, Mutlu M, Argün M. Comparison of simultaneous bilateral with unilateral total knee arthroplasty. *Acta Orthop Traumatol Turc.* 2014; 48: 127-135.
- Ritter MA, Harty LD, Davis KE, Meding JB, Berend M. Simultaneous Bilateral, Staged Bilateral, and Unilateral Total Knee Arthroplasty: A Survival Analysis. *J Bone Joint Surg Am.* 2003; 85: 1532-1537.
- Walker RH. Special report: Transfusion risks. *Am J Clin Pathol.* 1987; 88: 374-378.
- Charoencholvanich K, Siri wattanasakul P. Tranexamic Acid Reduces Blood Loss and Blood Transfusion after TKA: A Prospective Randomized Controlled Trial. *Clin Orthop Relat Res.* 2011; 469: 2874-2880.
- Kim TK, Chang CB, Kang YG, Seo ES, Lee JH, Yun JH, et al. Clinical value of tranexamic acid in unilateral and simultaneous bilateral TKAs under a contemporary blood-saving protocol: a randomized controlled trial. *Knee Surg Sports Traumatol Arthrosc.* 2013; 22: 1870-1878.
- Sabatini L, Trecci A, Imarisio D, Uslenghi MD, Bianco G, Scagnelli R. Fibrin tissue adhesive reduces postoperative blood loss in total knee arthroplasty. *J Orthop Traumatol.* 2012; 13: 145-51.
- Nielsen RE, Husted H. Tranexamic acid reduces blood loss and the need of blood transfusion after knee arthroplasty. *Ugeskr Laeger.* 2002; 164: 326-329.
- Burkart BC, Bourne RB, Rorabeck CH, Kirk PG, Nott L. The efficacy of tourniquet release in blood conservation after total knee arthroplasty. *Clin Orthop Relat Res.* 1994; 299: 147-152.
- Motifard M, Tahririan MA, Saneie M, Badiie S, Nemati A. Low Dose Perioperative Intravenous Tranexamic Acid in Patients Undergoing Total Knee Arthroplasty: A Double-Blind Randomized Placebo Controlled Clinical Trial. *J Blood Transfusion.* 2015; 2015: 948304.
- Bäthis H, Perlick L, Tingart M, Lüring C, Zurakowski D, Grifka J. Alignment in total knee arthroplasty a comparison of computer-assisted surgery with the conventional technique. *J Bone Joint Surg [Br].* 2004; 86: 682-687.
- Hafez MA. Custom made cutting guides for TKA. In: Install JN, Scott N, editors. *Surgery of the Knee.* 5th ed. Churchill Livingstone. 2012; 1240-1254.
- Klein GR, Austin MS, Smith EB, Hozack WJ. Total knee arthroplasty using computer-assisted navigation in patients with deformities of the femur and tibia. *J Arthroplasty.* 2006; 21: 284-288.
- Kuo SJ, Wang FS, Wang CJ, Ko JY, Chen SH, Siu KK. Effects of Computer Navigation versus Conventional Total Knee Arthroplasty on Endothelial Damage Marker Levels: A Prospective Comparative Study. *PLoS One.* 2015; 10: e0126663.
- Kotela A, Lorkowski J, Kucharzewski M, Wilk-Frańczuk M, Śliwiński Z, Frańczuk B, et al. Patient-Specific CT-Based Instrumentation versus Conventional Instrumentation in Total Knee Arthroplasty: A Prospective Randomized Controlled Study on Clinical Outcomes and In-Hospital Data. *Biomed Res Int.* 2015; 2015: 165908.
- Thienpont E. Faster recovery after minimally invasive surgery in total knee arthroplasty. *Knee Surg Sports Traumatol Arthrosc.* 2013; 21: 2370-2374.
- Yoon HS, Han CD, Yang IH. Comparison of simultaneous bilateral and staged bilateral total knee arthroplasty in terms of perioperative complications. *J Arthroplasty.* 2010; 25: 179-185.
- Stefańsdońtir A, Lidgren L, Robertsson O. Higher early mortality between simultaneous rather than staged bilateral TKAs results from the Swedish Knee Arthroplasty Register. *Clin Orthop Relat Res.* 2008; 466: 3066-3070.
- Berman AT, Geissele AE, Bosacco SJ. Blood loss with total knee arthroplasty. *Clin Orthop Relat Res.* 1988; 234: 137-138.
- Mostafa EA, Hafez MA, Khaled MA, Mohamed AR. PST shortens the operative time in total knee arthroplasty in comparison to a conventional technique. *Current Orthopaedic Practice.* 2016; 27: 187-191.
- Klika AK, Small TJ, Saleh A, Szubski CR, Chandran Pillai AL, Barsoum WK. Primary total knee arthroplasty allogenic transfusion trends, length of stay, and complications: Nationwide inpatient sample 2000 – 2009. *J Arthroplasty.* 2014; 29: 2070-2077.
- Skovgaard C, Holm B, Troelsen A, Lunn TH, Gaarn-Larsen L, Kehlet H, et al. No effect of fibrin sealant on drain output or functional recovery following simultaneous bilateral total knee arthroplasty A randomized, double-blind, placebo-controlled study. *Acta Orthop.* 2013; 84: 153-158.
- Muñoz M, Ariza D, Campos A, Martín-Montañez E, Pavía J. The cost of post-operative shed blood salvage after total knee arthroplasty: an analysis of 1,093 consecutive procedures. *Blood Transfus.* 2013; 11: 260-271.
- Moráis S, Ortega-Andreu M, Rodríguez-Merchán EC, Padilla-Eguiluz NG, Pérez-Chrzanoska H, Figueredo-Zalve R, et al. Blood transfusion after primary total knee arthroplasty can be significantly minimised through a multimodal blood-loss prevention approach. *Int Orthop.* 2014; 38: 347-354.
- Carling MS, Jeppsson A, Eriksson BI, Brisby H. Transfusions and blood loss in total hip and knee arthroplasty: a prospective observational study. *J Orthop Surg Res.* 2015; 10: 48.
- Burnett RS, Barrack RL. Computer-assisted total knee arthroplasty is currently of no proven clinical benefit: A systematic review. *Clin Orthop Relat Res.* 2013; 471: 264-276.

26. Kolettis GT, Wixson RL, Peruzzi WT, Blake MJ, Wardell S, Stulberg DS. Safety of 1-stage bilateral total knee arthroplasty. *Clin Orthop Relat Res.* 1994; 309: 102-109.
27. Lane GJ, Hozack WJ, Shah S, Rothman RH, Booth RE, Kenneth MS, et al. Simultaneous bilateral versus unilateral total knee arthroplasty. Outcomes analysis. *Clin Orthop Relat Res.* 1997; 345: 106-112.
28. Ritter MA, Hardy LD, Davis KE, John BM, Michael B. Simultaneous bilateral, staged bilateral, and unilateral total knee arthroplasty. A survival analysis. *J Bone Joint Surg Am.* 2003; 85: 1532-1537.
29. Spicer E, Thomas GR, Rumble EJ. Comparison of the major intraoperative and postoperative complications between unilateral and sequential bilateral total knee arthroplasty in a high-volume community hospital. *Can J Surg.* 2013; 56: 311-317.
30. Jankiewicz JJ, Sculco TP, Ranawat CS, Behr C, Tarrentino S. One-Stage versus 2-Stage Bilateral Total Knee Arthroplasty. *Clinical Orthopaedics & Related Research.* 1994; 309: 94-101.
31. Chareancholvanich K, Narkbunnam R, Pornrattanamaneeewong C. A prospective randomised controlled study of patient-specific cutting guides compared with conventional instrumentation in total knee replacement. *J Bone & Joint Surg.* 2013; 95: 354-359.
32. Thienpont E, Grosu I, Paternostre F, Schwab PE, Yombi JC. The use of patient-specific instruments does not reduce blood loss during minimally invasive total knee arthroplasty? *Knee Surg Sports Traumatol Arthrosc.* 2014; 23: 2055-2060.
33. John J Callaghan, Andrew Spitzer. Blood management and patient specific transfusion options in total joint replacement surgery. *Iowa Orthop J.* 2000; 20: 36-45.
34. Escobar A, Quintana JM, Bilbao A, Azkarate J, Guenaga JI, Arenaza JC, et al. Effect of patient characteristics on reported outcomes after total knee replacement. *Rheumatology (Oxford).* 2007; 46: 112-119.
35. Hatzidakis A, Mendlick R, McKillip T. The effect of preoperative autologous donation and other factors on the frequency of transfusion after total joint arthroplasty. 65th annual meeting of AAOS. New Orleans. 1998; 382.
36. Kreder HJ, Grosso P, Williams JI, Jaglal S, Axcell T, Wal EK, et al. Provider volume and other predictors of outcome after total knee arthroplasty: a population study in Ontario. *Can J Surg.* 2003; 46: 15-22.
37. Thienpont E, Paternostre F, Pietsch M, Hafez M, Howell S. Total knee arthroplasty with patient-specific instruments improves function and restores limb alignment in patients with extra-articular deformity. *The Knee.* 2013; 20: 407-411.