



## Comparison of functional outcome of simultaneous and staged bilateral total knee arthroplasty : systematic review of literature

Irfan QADIR, Latif KHAN, Jahanzeb MAZARI, Umair AHMED, Atiq uz ZAMAN, Amer AZIZ

*From the Department of Orthopaedic and Spine Surgery, Ghurki Trust Teaching Hospital, Lahore, Pakistan*

Safety of simultaneous bilateral TKA (simBTKA) and staged BTKA (staBTKA) have been compared in previous systematic reviews but functional outcome remains neglected aspect of the debate. We performed a systematic review of contemporary literature to compare the functional outcome of simBTKA and staBTKA.

We searched PubMed/MEDLINE, EMBASE and Cochrane Central Database to identify all articles published between 2000 and July 2020 that evaluated the outcome of patients undergoing BTKA either in simultaneous or staged manner.

Ten articles were identified which met the inclusion criteria. Functional outcome was reported in terms of Knee Society score (KSS), range of motion (ROM), Oxford Knee Score (OKS) and Western Ontario and McMaster University score (WOMAC) in seven, five, four and two studies respectively. KSS gained on average 66.6 points (47.5-95.3) for simBTKA and 65.1 points (44.4-97.2) for staBTKA without significant difference between two groups. There was no difference in post-operative ROM (maximum post-operative flexion being 124.4 and 125.1 for simBTKA and staBTKA groups respectively). Mean improvement in OKS ranged from 20 to 32.6 for simBTKA and 21.6 to 33.1 for staBTKA.

There was moderate evidence to suggest that both simultaneous BTKA and staged BTKA produce equivalent improvement in functional scores.

**Keywords :** Simultaneous ; staged ; bilateral ; total knee arthroplasty ; functional outcome.

### INTRODUCTION

Increasing life expectancy and high demand lifestyle combined with exceptional results of total knee arthroplasty have created huge rise in total knee arthroplasty (TKA) procedures performed each year. In the last two decades, number of TKAs performed per annum have nearly doubled (1). Approximately one third of patients have bilateral knee involvement at the time of presentation and 20% of patients who have undergone unilateral TKA require contralateral TKA within 2 years of index surgery (2-5).

Patients needing total knee arthroplasty for bilateral knee arthritis have the option of undergoing replacement simultaneously (simBTKA) or in a staged manner (staBTKA). When given the option, majority of patients opt to undergo a simBTKA

- 
- Irfan Qadir,
  - Latif Khan,
  - Jahanzeb Mazari,
  - Umair Ahmed,
  - Atiq uz Zaman,
  - Amer Aziz

*Department of Orthopaedic and Spine Surgery, Ghurki Trust Teaching Hospital, Lahore, Pakistan.*

Correspondence : Irfan Qadir, Department of Orthopaedic and Spine Surgery, Ghurki Trust Teaching Hospital, Jallo Mor Lahore, Pakistan. Phone : 0092 300 7321600.

Email : irfanqadir88@gmail.com,

© 2021, Acta Orthopædica Belgica.

---

(both procedures performed under 1 anesthesia) vs staBTKA (procedures performed on different days) (6,7). Number of simBTKA have gradually increased over the last 10 years and its results have been substantiated by several joint registries (8-11).

The potential benefits of simBTKA compared with staged procedures include a decreased length of hospitalization, time under anesthesia, rehabilitation time, and cost to the healthcare system. Furthermore, advocates of simBTKA contend that the procedure does not result in higher postoperative complications when compared with unilateral TKA while at the same time functional outcomes and patient satisfaction scores are comparable or even higher. SimBTKA is thought to be beneficial because a symptomatic arthritic knee can negatively influence patient's rehabilitation potential (12,13). On the other hand, published literature has also reported increased incidence of perioperative complications like pulmonary embolism, deep vein thrombosis, cardiac, neurologic and wound complications, and intensive care unit admissions to be associated with simBTKA. StaBTKA has been proposed to decrease the complication rate but at the same time raise the total cost of the procedure (14-16).

Safety of simBTKA and staBTKA have been assessed and compared in various systematic reviews and meta-analysis but functional outcome remains neglected aspect of the debate (1,2). We performed a systematic review of contemporary literature to compare the functional outcome of simBTKA and staBTKA.

## MATERIALS AND METHODS

Two reviewers (IQ and JM) independently searched PubMed/MEDLINE, EMBASE and Cochrane Central Database to identify all articles published between 2000 and July 2020 that evaluated the outcome of patients undergoing BTKA either in simultaneous or staged manner. Only restriction applied was English language. We used following search strategy: "bilateral" or "simultaneous" or "staged" or "1-staged" or "2-staged" AND "total knee arthroplasty" AND "total knee replacement", plus "clinical trial" AND "comparative study". Bibliography of each article

that met our inclusion criteria was also reviewed to identify additional relevant studies.

Two reviewers (IQ and JM) independently evaluated the titles and abstracts of the identified studies. Following inclusion criteria was applied: (1) studies including patients undergoing primary BTKA (2) studies comparing simBTKA with staBTKA and (3) studies including reported results included functional outcome. We excluded any studies comparing bilateral to unilateral TKA, studies that evaluated other knee arthroplasties, such as resurfacing or revision TKA, and studies that assumed that unilateral TKA performed twice was 2-stage bilateral TKA.

All the data was independently and carefully extracted from the eligible studies by 2 reviewers (IQ and LK). During preliminary review of the data, the following information was collected for each study: title, author, study design, number of patients, number of knees, age, gender,

American Society of Anesthesiologists (ASA) score, knee functional outcome (in terms of Knee Society Score, Oxford Knee Score, Western Ontario and McMaster Universities Osteoarthritis Index, range of motion and Short Form 36 score).

Based on the Cochrane Bone, Joint and Muscle Trauma Group (17), assessment of the methodological quality of each included study was made by the 2 reviewers (IQ and LK). Any dispute was cross-checked and resolved by a third author (AUZ) to reach a final consensus. In addition, we contacted the corresponding author of each eligible study to verify the accuracy of our data abstraction as well as to provide additional information that had not been reported in the published studies.

## RESULTS

The search resulted in 873 abstracts (Fig. 1). Inclusion and exclusion criteria were then applied and thirty-eight articles were reviewed for eligibility. Twenty-eight articles were excluded due to missing outcome of interest. In the final analysis, ten articles were included (9,18-26).

Seven retrospective (9,18,19,22-25) and three prospective (20,21,26) cohort studies with 4043 patients were selected for inclusion in this systematic

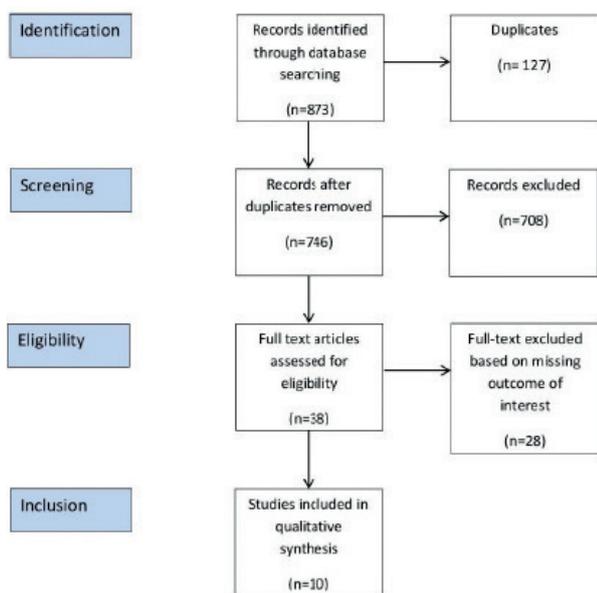


Figure 1. — Systematic review flow diagram.

analysis. Of these, 2226 patients and 1817 patients underwent simBTKA and staBTKA respectively. Details on all of the studies were shown in Table 1. The majority of patients included in these studies were females (72.7% and 72.8% of patients in the simBTKA and staBTKA groups, respectively), while the mean age ranged from 63 (24) to 73 years (21) in the simBTKA group and from 62.1 (20) to 71.2 years (21) in the staBTKA group.

Six of 10 studies reported the baseline demographics (including age, gender, body mass index) of the 2 groups to be statistically similar (20-23,25,26). Lee et al. (24) reported that simBTKA patients to be significantly younger than staBTKA. Hutchinson et al. (19) reported a higher propensity of simBTKA patients to be males. Forster et al. (18) found that patients undergoing staBTKA had higher BMI while patients who had simBTKA had poor preoperative KSS scores.

5 studies (18,22,24-26) also reported no significant differences in ASA scores or co-morbidities between the 2 groups while rest of the studies did not assess preoperative co-morbidities (19-21,23). Preoperative clinical/functional scores and deformities were found to be similar between both groups in seven studies (19-25). All the studies except [Hooper] et al. (9) provided mean time interval between the 2

procedures of staBTKA (mean time range 36.6 days (25) to 34 months (19)). All the studies had a minimum follow up of 1 year and upto 148 months (19).

All 10 studies reported functional outcome in terms of various clinical scoring systems (9,18-26). The most commonly used scoring system was the Knee Society Score (KSS) (18-22,24,25); range of motion (ROM) was reported in 5 papers (19,21,22,24,25), Oxford Knee Score (OKS) in 4 papers (9,23,24,26) and Western Ontario and McMaster Universities osteoarthritis Index in 2 papers (20,25). Lee et al. (24) used 36-Item Short-Form Health Survey and Goyal et al. (26) used 12 item SF health survey.

Five out of seven studies analyzing the KSS knee-specific subscore (18-22,24,25), reported both preoperative and postoperative measurements (18,19,22,24,25). While 1 study (20) documented only the postoperative values and another one (21) stated that simBTKA and staBTKA had similar trends without providing with specific values. Regarding the KSS functional-specific subscore, only 2 studies reported data before and after the procedures (18,24), while another study reported temporal trends in Functional scores over 13 post-operative months (21).

KSS knee-specific subscore gained on average 66.6 points (47.5-95.3) for the simBTKA and 65.1 points (44.4-97.2) for the staBTKA, so that all studies examining KSS knee-specific subscore noted a significant improvement in both simBTKA and staBTKA (18-22,24,25). However, no significant difference was found between the two procedures.

Amongst the studies which looked at OKS (9,23,24,26), Abram et al. (23) reported preoperative and 1-year postoperative data, Lee et al. (24) reported data before and 2 year after the procedures whereas Goyal and Hooper et al. (9,26) documented only the 6-month postoperative OKS.

Abram et al. (23) found a mean improvement of 22.2 and 24 for staBTKA and simBTKA, respectively. Lee et al. (24) reported a mean improvement of 21.6 and 20 for staBTKA and simBTKA, respectively. Hooper et al. (9) reported 6-month postoperative OKS with a mean value of 22.6 and 21.7 for staBTKA and simBTKA, respectively. Finally, Goyal et al. (26) also reported 6-month postoperative

Table 1. — General Characteristics of included studies

Study	Year	Design	Level of Evidence	Country	Total			Simultaneous			Staged			Interval	Outcome
					N	M/F	Age	N	M/F	Age	N	M/F	Age		
<b>Forster (18)</b>	2006	Retrospective	III	Australia	102	28	15/13	66 (51-70)	74	34/40	64 (41-79)	36 patients-1 week 38 patients - Mean 29 months (5-68)	KSS & HSS at 6 and 12 months		
<b>Hutchinson (19)</b>	2006	Retrospective	III	Australia	563	438	245/193	67	125	46/79	65	34 months (2-120)	KSS & ROM at 1, 5, 10 years		
<b>Hooper (9)</b>	2009	Retrospective	III	New Zealand	1186	506	-	65(18-87)	680	-	69 (30-93)	-	OKS at 6 months		
<b>Bulbul (20)</b>	2011	Prospective	II	Turkey	50	24	8/16	64.3(58-75)	26	7/19	62.1 (57-74)	3 months	WOMAC & KSS at 6 & 12 months		
<b>Nilki (21)</b>	2014	Prospective	II	Japan	120	60	10/50	73±7.9	60	10/50	71.2±7.1 72.3±7.1	8.2 months (3-14)	Temporal trends of KSS, FS, ROM over 13 months		
<b>Zhao (22)</b>	2015	Retrospective	III	China	93	54	6/48	66.9±7.1	39	5/34	67.2±7.8	9 months (2-36)	KSS & ROM at 1 year		
<b>Seol (25)</b>	2016	Retrospective	III	South Korea	1074	759	43/716	68.3±4.1	315	25/290	66±4.1	36.6 days	KSS, FS, WOMAC, ROM at last followup (51.59±7.53)		
<b>Lee (24)</b>	2016	Retrospective	III	Singapore	67	29	3/26	63±8	38	3/35	68±7	174±87 days	OKS, KSS, FS, ROM, SF-36 at 2 years		
<b>Abram (23)</b>	2016	Retrospective	III	UK	328	78	29/49	65(34-81)	250	84/166	66 (42-92)	23 months (2-74)	OKS at 1 year		
<b>Goyal (26)</b>	2020	Prospective	II	India	460	250	110/140	67.7±9.7	210	95/115	66.5±10.4	1.6 months (3wk-12 months)	OKS, SF-12 at 6 months		

OKS with a mean value of 33.1 and 32.6 for staBTKA and simBTKA, respectively. Overall, all 4 studies examining postoperative OKS concluded that there was no significant difference between the 2 procedures (9,23,24,26).

Both studies using the Western Ontario and McMaster Universities Osteoarthritis Index score found that there were no postoperative significant difference amongst the two groups (20,25). Seol et al. (25) found an improvement in WOMAC score of 56.6 and 52.8 points for simBTKA and staTKA groups.

Among studies that looked at ROM (19,21,22,24,25), except Niki et al. (21) all studies documented both preoperative and postoperative data to determine the efficacy of simBTKA and staBTKA and found no difference in post-operative ROM between the two groups (19,22,24,25). Maximum post-operative flexion reported was 124.4 and 125.1 for simBTKA and staBTKA groups respectively.

## DISCUSSION

The purpose of this review was to provide insight about the functional outcome of simultaneous and staged BTKA. Recent systematic review by Malahias et al. (2) and meta-analysis by Liu et al. (1) have extensively studied the safety of simBTKR. Malahias et al. (2) concluded that in studies involving comparable baseline demographics of patients, there was moderate evidence to show that simultaneous BTKA was as safe as the staged BTKA. Functional outcome, however, remains neglected aspect of the debate. This is partly due to lack of high quality randomized control trials but also because of heterogenous results of retrospective studies which use myriad of different functional scoring systems as well as difference in baseline patient demographics which makes comparison difficult.

In addition to the risk of perioperative complications after simBTKA and staBTKA, functional outcome is an important consideration for the decision making and consent procedure as published evidence supports score 'improvement' as a key determinant of patient satisfaction after arthroplasty (27). It is important to recognize that a staged procedure delays the full benefits of bilateral TKA

until both surgeries are performed. Additionally, in patients with bilateral knee osteoarthritis who have large flexion contractures, the presence of contralateral painful knee makes successful postoperative rehabilitation more difficult when TKA is conducted in a staged manner. It has been hypothesized that the increased loading in the contralateral knee of a patient having a TKA could lead to osteoarthritis progression in that knee (5). Clinical studies have reported that 20% of patients undergoing unilateral TKA require contralateral TKA within 2 years of index surgery (2-5). Different staging intervals, ranging from 3 weeks to several months, have been employed in various studies. Some authors have proposed staggered BTKR, involving sequential surgery of both knees during same hospital admission 5 to 7 days apart (18,28-30). Focus of these staging intervals has been to expediate functional recovery while minimizing complications.

The results of our study indicate both simBTKA and staBTKA result in significant improvement in functional score compared to preoperative status, thereby confirming the effectiveness of BTKR. However, there is no significant difference between the two procedures with regards to functional improvement. These results, however, should be interpreted with caution as the overall quality of the studies included in this review was not high. Majority of the studies were retrospective and there were no level I randomized controlled trials and, as such, all studies were susceptible for various types of potential bias. Furthermore, the time interval between the first and the second surgery in patients undergoing staBTKA varied widely among studies. Follow-up duration was variable amongst studies with maximum duration being 2 years. No studies with long term follow-up were available. Four out of ten studies had heterogenous patient population and this difference in baseline characteristics could influence their results. Therefore, further studies of higher quality are required to lead to definitive conclusions in relation to the functional improvement after simBTKA compared with staBTKA.

## CONCLUSION

There was moderate evidence to suggest that both simultaneous BTKA and staged BTKA produce equivalent improvement in functional scores.

## REFERENCES

- Liu L, Liu H, Zhang H, Song J, Zhang L.** Bilateral total knee arthroplasty : Simultaneous or staged? A systematic review and meta-analysis. *Medicine.* 2019 ; 98(22) : e15931.
- Malahias MA, Gu A, Adriani M, Addona JL, Alexiades MM, Sculco PK.** Comparing the Safety and Outcome of Simultaneous and Staged Bilateral Total Knee Arthroplasty in Contemporary Practice : A Systematic Review of the Literature. *J Arthroplasty.* 2019 ; 34(7) : 1531-7.
- Seo JG, Lee BH, Moon YW, Chang MJ, Park SH.** Disparate postoperative results in the first and second knees on simultaneous bilateral total knee arthroplasty. *J Arthroplasty.* 2014 ; 29(12) : 2331-6.
- Meehan JP, Danielsen B, Tancredi DJ, Kim S, Jamali AA, White RH.** A population-based comparison of the incidence of adverse outcomes after simultaneous-bilateral and staged-bilateral total knee arthroplasty. *J Bone Joint Surg Am.* 2011 ; 93(23) : 2203-13.
- Meehan JP, Monazzam S, Miles T, Danielsen B, White RH.** Postoperative Stiffness Requiring Manipulation Under Anesthesia Is Significantly Reduced After Simultaneous Versus Staged Bilateral Total Knee Arthroplasty. *J Bone Joint Surg Am.* 2017 ; 99(24) : 2085-93.
- 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(8) : 1532-7.
- Bagsby D, Pierson JL.** Functional outcomes of simultaneous bilateral versus unilateral total knee arthroplasty. *Orthopedics.* 2015 ; 38(1) : e43-7.
- Lindberg-Larsen M, Jørgensen CC, Husted H, Kehlet H.** Early morbidity after simultaneous and staged bilateral total knee arthroplasty. *Knee surg, sports traumatol, arthroscopy.* 2015 ; 23(3) : 831-7.
- Hooper GJ, Hooper NM, Rothwell AG, Hobbs T.** Bilateral total joint arthroplasty : the early results from the New Zealand National Joint Registry. *J Arthroplasty* 2009 ; 24(8) : 1174-7.
- Kim YH, Choi YW, Kim JS.** Simultaneous bilateral sequential total knee replacement is as safe as unilateral total knee replacement. *J Bone Joint Surg Brit.* 2009 ; 91(1) : 64-8.
- Hadley S, Day M, Schwarzkopf R, Smith A, Slover J, Zuckerman J.** Is Simultaneous Bilateral Total Knee Arthroplasty (BTKA) as Safe as Staged BTKA? *Am J Orthop (Belle Mead, NJ).* 2017 ; 46(4) : E224-e9.
- Haddad B, Khan W, Mehta V, Mbubaegbu C, Qamar A.** Bilateral Simultaneous Total Knee Arthroplasty : A Patient-Matched Retrospective Observational Study. *Open Orthop J.* 2015 ; 9 : 499-503.
- Latifi R, Thomsen MG, Kallemose T, Husted H, Troelsen A.** Knee awareness and functionality after simultaneous bilateral vs unilateral total knee arthroplasty. *World J Orthop.* 2016 ; 7(3) : 195-201.
- Fu D, Li G, Chen K, Zeng H, Zhang X, Cai Z.** Comparison of clinical outcome between simultaneous-bilateral and staged-bilateral total knee arthroplasty : a systematic review of retrospective studies. *J Arthroplasty* 2013 ; 28(7) : 1141-7.
- Memsoudis SG, Gonzalez Della Valle A, Besculides MC, Gaber L, Sculco TP.** In-hospital complications and mortality of unilateral, bilateral, and revision TKA : based on an estimate of 4,159,661 discharges. *Clin Orthop Rel Res.* 2008 ; 466(11) : 2617-27.
- Adili A, Bhandari M, Petruccioli D, De Beer J.** Sequential bilateral total knee arthroplasty under 1 anesthetic in patients > or = 75 years old : complications and functional outcomes. *J Arthroplasty* 2001 ; 16(3) : 271-8.
- Handoll HH, Gillespie WJ, Gillespie LD, Madhok R.** Moving towards evidence-based healthcare for musculoskeletal injuries : featuring the work of the Cochrane Bone, joint and Muscle Trauma Group. *The journal of the Royal Society for the Promotion of Health.* 2007 ; 127(4) : 168-73.
- Forster MC, Bauze AJ, Bailie AG, Falworth MS, Oakeshott RD.** A retrospective comparative study of bilateral total knee replacement staged at a one-week interval. *J Bone Joint Surg Brit* 2006 ; 88(8) : 1006-10.
- Hutchinson JR, Parish EN, Cross MJ.** A comparison of bilateral uncemented total knee arthroplasty : simultaneous or staged? *J Bone Joint Surg Brit.* 2006 ; 88(1) : 40-3.
- Bülbül M, Ayanoğlu S, İmren Y, Dedeoğlu S, Esenyeş CZ, Gürbüz H.** Assessment of functional outcomes of either simultaneous or staged bilateral total knee arthroplasty at year one. *Assessment.* 2011 ; 26 : 29.
- Niki Y, Katsuyama E, Takeda Y, Enomoto H, Toyama Y, Suda Y.** Comparison of postoperative morbidity between simultaneous bilateral and staged bilateral total knee arthroplasties : serological perspective and clinical consequences. *J Arthroplasty* 2014 ; 29(3) : 504-9.
- Zhao YT, Chu HJ, Heng DF, Lei J.** Comparison of the effectiveness and safety of one-stage versus two-stage bilateral total knee arthroplasty. *Acta Orthop Belgica.* 2015 ; 81(4) : 784-9.
- Abram SG, Nicol F, Spencer SJ.** Patient reported outcomes in three hundred and twenty eight bilateral total knee replacement cases (simultaneous versus staged arthroplasty) using the Oxford Knee Score. *Internat Orthop.* 2016 ; 40(10) : 2055-9.
- Lee WC, Kwan YH, Yeo SJ.** Severe Bilateral Fixed Flexion Deformity-Simultaneous or Staged Total Knee Arthroplasty? *J Arthroplasty* 2016 ; 31(1) : 128-31.

25. **Seol JH, Seon JK, Song EK.** Comparison of postoperative complications and clinical outcomes between simultaneous and staged bilateral total knee arthroplasty. *J Orthop Science.* 2016 ; 21(6) : 766-9.
26. **Goyal T, Azam MQ.** Simultaneous single-stage versus two-staged bilateral total knee arthroplasty : a prospective comparative study. 2020 ; 44(7) : 1305-10.
27. **Judge A, Arden NK, Kiran A, Price A, Javaid MK, Beard D, et al.** Interpretation of patient-reported outcomes for hip and knee replacement surgery : identification of thresholds associated with satisfaction with surgery. *J Bone Joint Surg Brit.* 2012 ; 94(3) : 412-8.
28. **Sliva CD, Callaghan JJ, Goetz DD, Taylor SG.** Staggered bilateral total knee arthroplasty performed four to seven days apart during a single hospitalization. *J Bone Joint Surg Am.* 2005 ; 87(3) : 508-13.
29. **Alosh H, Shah RP, Courtney PM, Virk S, Israelite CL.** One-week staged bilateral total knee arthroplasty protocol : a safety comparison of intended and completed surgeries. *J Arthroplasty* 2014 ; 29(6) : 1176-80.
30. **Courtney PM, Melnic CM, Alosh H, Shah RP, Nelson CL, Israelite CL.** Is bilateral total knee arthroplasty staged at a one-week interval safe? A matched case control study. *J Arthroplasty* 2014 ; 29(10) : 1946-9.