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Comparative Analysis of the Immediate Post-operative Outcomes between Conventional and Fully Automatic Robotic-assisted Total Knee Arthroplasty

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Abstract

Background: Different techniques employed during conventional and robotic-assisted total knee arthroplasty (TKA) may lead to variation in the immediate post-operative outcomes. Primary objective of the study was to evaluate the differences in post-operative pain, analgesics use, and length of stay between the robotic assisted (RA-TKA) and conventional (C-TKA). Secondary objective was to study the patient-reported outcome measures at 6-month post-TKA.

Materials and Methods: It is a retrospective review of two cohorts of patients (C-TKA and RA-TKA) who were operated between January and April 2022. Patients were given the option between C-TKA and RA-TKA. Sample size was estimated to be 28 patients in each group with α error of 0.05 and power of study being 80%. An independent observer analyzed the post-operative parameters such as analgesic use, length of stay, visual analog scale (VAS) score, and Oxford Knee Score (OKS) at 6-month post-TKA.

Results: 30 patients in two cohorts were studied. There was no statistically significant difference between the two cohorts as regards the pre-operative patient characteristics. RA-TKA group had a shorter hospital stay (days) than the C-TKA group (3.24 ± 0.50 and 4.07 ± 0.52, P < 0.0001). Pain score (VAS score) was lower in RA-TKA than C-TKA cohort (post-operative day [POD1] 5.23 ± 0.50 and 5.93 ± 0.52 POD2 4.40 ± 0.56 and 5.03 ± 0.49, P < 0.0001). R-TKA patients required significantly lower morphine milligram equivalent and non-steroidal anti-inflammatory drugs than the C-TKA patients (P = 0.0005 and P < 0.001, respectively). The OKS at 6 months was lower in C-TKA than RA-TKA (32.5 ± 2.3 C-TKA vs. 33.8 ± 1.5 RA-TKA, P = 0.0120).

Conclusion: RA-TKA cohort showed significant early advantages such as decreased post-operative analgesia usage, shorter length of stay, and lower pain scores on days 1 and 2 than the C-TKA group. The OKS at 6 months was slightly better in RA-TKA versus C-TKA.

Keywords: Robotic-assisted total knee arthroplasty, conventional total knee arthroplasty, visual analog scale score, analgesic.

Introduction

Total knee arthroplasty (TKA) is a highly successful operation for end-stage knee osteoarthritis. However, not every TKA provides a patient with an ideal knee post-operatively [1, 2]. The patients may have unresolved pain and suboptimal patient-reported outcome [3, 4]. To minimize these unhappy patients, computer navigation and robotic-assisted technology have been introduced in the past 2 decades. Various studies have shown that these technologies are helpful in predicting the correct implant size and achieving precise implant and limb alignment [5, 6]. A study by Mannan et al. showed the usefulness of robotic assistance in improving the coronal plane alignment [7]. Because of these factors, the use of robotic assistance in TKA is on the rise. In today's cost-conscious environment, the obvious question is whether these better technical outcomes with the use of robotic-assisted TKA (RA-TKA) result in better clinical outcomes than the conventional TKA (C-TKA). There are very few studies being done to answer these questions. A study by Kayani et al.

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[8] showed improved early functional recovery and decreased hospital discharge time with robotic arm-assisted TKA as compared to conventional TKA. A study by Marchand et al. [9] showed decreased pain up to 6-month post-TKA with the use of robotic arm-assisted TKA. Both these studies were done with the use of Mako robotic arm-assisted technology (Stryker, Mahesh, NJ). The possible explanation for this is minimal handling of the soft tissue due to the use haptic boundary for saw bone cutting. We planned to expand upon this knowledge with a cohort of TKA patients who underwent fully active robotic-assisted TKA (Cuvis Joint active Robot, Curexo, Korea) which utilizes robotic arm-controlled bone milling burr for accurate bony resection. The primary objective of the present study was to evaluate the differences in the post-operative pain, use of analgesics, and length of stay between the fully automatic RA-TKA and C-TKA. The secondary objective was to study the patient-reported outcome measures (PROMS), Oxford Knee Score (OKS) between the two cohorts at 6-month post-TKA. The difference in pain if any, between the two cohorts, is important from the point of view day care TKA/accelerated TKA.

Materials and Methods

We retrospectively reviewed two cohorts of patients, i.e., patients undergoing C-TKA and fully automatic robotic-assisted TKA. Sample size was estimated to be 28 patients in each group with α error of 0.05 and power of study being 80%. Considering the dropouts, the figure was rounded to 30 patients in each group. The inclusion criteria were patients undergoing the aforementioned procedures for Kellgren-Lawrence grade 4 osteoarthritis or advanced rheumatoid arthritis of the knee from February 2022 to May 2022. Patients were given option between C-TKA and RA-TKA. Patients who had previous surgery on the to-be-operated knee and patients with post-traumatic arthritis of the knee were excluded from the study. Before the commencement of the study, institutional review board approval was obtained. An informed consent was taken from each study participant. All the patients were operated by the same surgical team. All the patients received posterior stabilized high flexion bone conserving TKA through medial para patellar approach. Tourniquet was used in all cases. All patients were operated under spinal anesthesia. Post-TKR procedure an adductor canal block under ultrasonography guidance was given by the anesthetist. Antibiotic prophylaxis was with first-generation injectable cephalosporin given on induction and post-TKA procedure at 6 and 12 h post-operatively. Post-operative analgesia was with injectable tramadol depending upon the intensity of pain. For breakthrough pain, injectable non-steroidal anti-inflammatory drugs (NSAIDS), i.e., diclofenac were used in patients with normal renal function. DVT prophylaxis was with injectable enoxaparin on day 1 followed by 10 mg of rivaraxoban given once a day for 14 days. Post-operative rehabilitation was in the form of knee, hip, and ankle range of motion and muscle strengthening exercises and mobilization with the help of walker. Patients were discharged when they could manage commode sitting and climbing the stairs. Post-operative parameters such as post-TKA pain, consumption of analgesics (tramadol and NSAIDS), and days to discharge were studied. Post-TKA pain was assessed with patient filled visual analog scale (VAS) score questionnaire. As regards the post-TKA analgesia requirement, number of NSAIDS doses used and morphine equivalent tramadol utilized was calculated. Patient-reported outcome measure was studied with OKS at 6-month post-TKA. All these post-operative parameters are studied by an independent observer who was not part of surgical team.

Results

Pre-operative patient characteristics were similar between the two study group cohorts (Table 1). The RA-TKA group had significantly less pain as judged with VAS score on post-operative days 1 and 2 as compared to CA-TKA group. (Table 2) The VAS score for C-TKA and R-TKA cohort on post-operative day [POD1] was 5.93 ± 0.52 and 5.23 ± 0.50, respectively (statistically significant, $P < 0.0001$. The same for C-TKA and R-TKA cohort on POD2 was 5.03 ± 0.49 and 4.40 ± 0.56, respectively (statistically significant, $P < 0.0001$). The analgesic consumption, both number of morphine equivalent analgesics and NSAIDS, was lower in RA-TKA group than CA- TKA group. (Table 3) Patients

Table 1: Comparison of pre-operative patient characteristics between conventional and robotic-assisted TKA patients

Parameters	Conventional TKA	Robotic-assisted TKA	*P*-value
Number of patients (*n*)	30	30	-
Mean age (years)	65.2±12.8	64.5±13.5	0.8374
Mean BMI (kg/m^2)	28.3±4.2	27.2±5.3	0.3766
Mean pre-operative VAS score	7.5±1.5	7.4±1.6	0.8037
Pre-operative range of motion	95.5±17.5	97.1±15.4	0.7083
Pre-operative degree of deformity	8.1±2.4	7.5±2.5	0.3469
Pre-operative associated co-morbidity			
Cardiac	*n*=8 (26.67%)	*n*=11 (36.67%)	0.409
Renal	*n*=6 (20.0%)	*n*=8 (26.67%)	0.5447
Respiratory	*n*=2 (6.67%)	*n*=3 (10.00%)	0.6436
Pre-operative clinical diagnosis (%)			
OA	*n*=28 (93.33%)	*n*=27 (90.00%)	0.6436
RA	*n*=02 (6.66%)	*n*=03 (10.00%)	0.6425

TKA: Total knee arthroplasty, BMI: Body mass index, VAS: Visual analog scale

Table 2: Pain score (VAS) on post-operative days 1 and 2

Parameter	Conventional TKA	Robotic-assisted TKA	*P*-value
Post-operative day 1	5.93±0.52	5.23±0.50	<0.0001
Post-operative day 2	5.03±0.49	4.40±0.56	<0.0001

VAS: Visual analog scale, TKA: Total knee arthroplasty

Table 3: Post-operative analgesic requirement on days 1 and 2

Parameter	Conventional TKA	Robotic-assisted TKA	*P*-value
Morphine equivalent	24.67±3.20	21.83±2.78	0.0005
NSAIDS injections	3.10±1.18	1.90±0.84	<0.0001

NSAIDS: Non-steroidal anti-inflammatory drugs, TKA: Total knee

Table 4: Comparison of length of stay between C-TKA and R-TKA

Parameter	Conventional TKA	Robotic assisted TKA	*P*-value
Length of stay (days)	4.07±0.52	3.24±0.50	<0.0001

C-TKA: Conventional total knee arthroplasty, R-TKA: Robotic-assisted total knee arthroplasty

Table 5: Post-operative oxford knee score at 6 months

Parameter	Conventional TKA	Robotic-assisted TKA	*P*-value
Oxford knee score	32.50±2.30	33.80±1.50	0.012

TKA: Total knee arthroplasty

in RA-TKA group were discharged earlier than those with CA-TKA group (Table 4). The length of stay in C-TKA and RA-TKA cohort was 4.07 ± 0.52 and 3.24 ± 0.50, respectively (statistically significant, P < 0.0001). The OKS at 6-month post-TKA was slightly better in RA-TKA group than CA-TKA group (Table 5). The OKS at 6 months in RA-TKA cohort was 33.80 ± 1.50 as against 32.50 ± 2.30 in C-TKA cohort (statistically significant, P = 0.0120).

Discussion

The main findings of our study were that the patients in RA-TKA cohort had less post-operative pain on post-operative days 1 and 2 than the patients in CA-TKA cohort. Furthermore, the RA-TKA cohort had shorter length of stay and significantly lower NSAIDS and morphine milligram equivalent analgesics consumption than the CA-TKA cohort. The PROMS and OKS were better in RA-TKA cohort than the CA-TKA cohort. While various studies have shown that robotic-assisted TKA achieves better technical outcomes as judged by hip-knee ankle axis, implant, and limb alignment, fewer studies have demonstrated superior clinical outcomes [10]. To the best of our knowledge, ours is the first study of its kind which evaluated and compared the immediate post-operative clinical outcomes between fully automatic RA-TKA and CA-TKA cohort. The lower POD1 and 2 VAS score can be attributed to the accurate pre-operative planning as regards the femur and tibia cuts thereby minimizing the need for soft-tissue releases. The decreased NSAIDS and morphine milligram equivalent doses are beneficial in the context of increasing popularity of daycare surgery and accelerated discharge after TKA. The lower length of stay in RA-TKA is useful in reducing the overall health-care costs. The differences between the RA-TKA and CA-TKA cohorts as regards VAS scores and decreased analgesic usage can be due to three technique-related differences between the two procedures. The RA-TKA uses stereotactic haptic boundary to constrain the bone mill while making the bony cuts. This results in decreased iatrogenic soft-tissue damage [11]. Hampp et al. [12] in his cadaveric study showed less iatrogenic soft-tissue damage in RA-TKA than C-TKA. Kayani et al. in his clinical study also showed decreased soft-tissue damage with RA-TKA than C-TKA. They showed better early straight leg raise, better VAS score, and reduced length of stay in RA-TKA cohort than C-TKA cohort (30 patients in each group) [13]. Ra-TKA reduces the need of tibial subluxation during the procedure which may lead to lesser soft-tissue insult. In RA-TKA, tibial subluxation is required only during component implantation. In C-TKA, tibial subluxation is necessary for resection of the proximal tibia to protect the posterior soft tissues. The third technical difference between RA-TKA and C-TKA is the utilization of the three-dimensional computed tomography for planning and while assessing the intraoperative gap balancing in RA-TKA. This leads to improved sagittal and coronal plane alignment throughout the knee range of motion thereby minimizing the pain [14, 15, 16].

In our study, the RA-TKA cohort had better patient-reported outcome measure (OKS) than C-TKA cohort. This is in contrast to the findings of the study by Clark et al. [17] who found no significant difference between computer-navigated TKA and RA-TKA. They had similar PROMS at any point of time from 3-month to 2-year post-TKA procedure.

The strength of our study is that to the best of our knowledge, ours is the first of its kind study which evaluated and compared the immediate post-operative outcomes between the fully automatic RA-TKA and C-TKA. Our study has certain limitations. The first limitation is it is retrospective study and not a randomized prospective study. However, the results between the cohorts can be compared as the pre-operative patient characteristics of the two cohorts of patients were similar (Table 1). The second limitation is that the OKS was studied at 6-month post-TKA. A longer follow-up and assessment of PROM are necessary. We are continuing to evaluate these two cohorts of patients to see the differences in the PROM at a longer follow-up times.

Conclusion

Our study demonstrated significant early advantages such as decreased length of stay and lower post-operative analgesia use in RA-TKA than C-TKA. The pain scores on post-operative days 1 and 2 were also significantly lower in RA-TKA group than in the C-TKA group. The OKS was slightly better in RA-TKA than C-TKA at 6 months. Further, follow-up of these patients is underway to see the differences in PROMS at longer follow-up.

Declaration of patient consent: The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient has given his consent for his images and other clinical information to be reported in the Journal. The patient understands that his name and initials will not be published, and due efforts will be made to conceal his identity, but anonymity cannot be guaranteed.

Conflict of Interest: NIL; **Source of Support:** NIL

References

1. Bourne RB, Chesworth BM, Davis AM, Mahomed NN, Charron KD. Patient satisfaction after total knee arthroplasty: Who is satisfied and who is not? Clin Orthop Relat Res 2010;468:57-63.
2. Kahlenberg CA, Nwachukwu BU, McLawhorn AS, Cross MB, Cornell CN, Padgett DE. Patient satisfaction after total knee replacement: A systematic review. HSS J 2018;14:192-201.
3. Mannan A, Vun J, Lodge C, Eyre-Brook A, Jones S. Increased precision of coronal plane outcomes in robotic-assisted total knee arthroplasty: A systematic review and meta-analysis. Surgeon 2018;16:237-44.
4. Jones CA, Voaklander DC, Suarez-Almazor ME. Determinants of function after total knee arthroplasty. Phys Ther 2003;83:696-706.
5. Lim HA, Song EK, Seon JK, Park KS, Shin YJ, Yang HY. Causes of aseptic persistent pain after total knee arthroplasty. Clin Orthop Surg 2016;9:50-6.
6. Jones CW, Jerabek SA. Current role of computer navigation in total knee arthroplasty. J Arthroplast 2018;33:1989-93.
7. Petursson G, Fenstad AM, Gøthesen O, Dyrhovden GS, Hallan G, Röhrl SM, et al. Computer-assisted compared with conventional total knee replacement. J Bone Joint Surg Am 2018;100:1265-74.
8. Kayani B, Konan S, Tahmassebi J, Pietrzak JR, Haddad FS. Robotic-arm assisted total knee arthroplasty is associated with improved early functional recovery and reduced time to hospital discharge compared with conventional jig-based total knee arthroplasty: A prospective cohort study. Bone Joint J 2018;100-B:930-7.
9. Marchand RC, Sodhi N, Khlopas A, Sultan AA, Harwin SF, Malkani AL, et al. Patient satisfaction outcomes after robotic arm-assisted total knee arthroplasty: A short-term evaluation. J Knee Surg 2017;30:849-53.
10. Naziri Q, Burekhovich SA, Mixa PJ, Pivec R, Newman JM, Shah NV, et al. The trends in robotic-assisted knee arthroplasty: A statewide database study. J Orthop 2019;16:298-301.
11. Khlopas A, Chughtai M, Hampp EL, Scholl LY, Prieto M, Chang TC, et al. Robotic-arm assisted total knee arthroplasty demonstrated soft tissue protection. Surg Technol Int 2017;30:441-6.
12. Hampp EL, Chughtai M, Scholl LY, Sodhi N, Bhowmik-Stoker M, Jacofsky DJ, et al. Robotic-arm assisted total knee arthroplasty demonstrated greater accuracy and precision to plan compared with manual techniques. J Knee Surg 2018;32:239-50.
13. Kayani B, Konan S, Pietrzak JR, Haddad FS. Iatrogenic bone and soft tissue trauma in robotic-arm assisted total knee arthroplasty compared with conventional jig-based total knee arthroplasty: A prospective cohort study and validation of a new classification system. J Arthroplast 2018;33:2496-501.
14. Nicoll D, Rowley DI. Internal rotational error of the tibial component is a major cause of pain after total knee replacement. J Bone Joint Surg Br 2010;92:1238-44.
15. Kayani B, Konan S, Pietrzak JR, Huq SS, Tahmassebi J, Haddad FS. The learning curve associated with robotic-arm assisted unicompartmental knee arthroplasty. Bone Joint J 2018;100-B:1033-42.
16. Kayani B, Konan S, Ayuob A, Onochie E, Al-Jabri T, Haddad FS. Robotic technology in total knee arthroplasty: A systematic review. EFORT Open Rev 2019;4:611-7.
17. Clark G, Steer R, Tippett B, Wood D. Short-term benefits of robotic assisted total knee arthroplasty over computer navigated total knee arthroplasty are not sustained with no difference in postoperative patient-reported outcome measures. Arthroplast Today 2022;14:210-5.e0.

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