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# Is Robotic TKA Having Added Advantage over Conventional TKA? A Comparative Study of Functional and Radiological Outcome of Robotic versus Conventional Total Knee Arthroplasty

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## Abstract

**Objective** Total knee arthroplasty (TKA) is most commonly performed procedure in patients who are not showing improvement in pain, activities of daily living, and quality of life by conservative modalities. Precise component implantation and soft tissue management is required to achieve desired outcome following TKA. 1.3% patients remain disappointed due to persistent pain, 24% due to instability, and 2.5% due to malalignment following TKA. Robotic TKA is associated with the use of customized implants and bone cuts leading to precise component implantation and reduced deviation from mechanical axis in coronal, transverse, and sagittal plane and proper soft tissue management. This study compares conventional against robotic TKA in terms of clinical, functional, and radiological outcome.

**Materials and Methods** This is a prospective randomized control trial carried over period of 3 years where patients were selected on the basis of inclusion and exclusion criteria and were randomly divided into both groups and compared using their pre- and postoperative radiological and functional outcomes as well as intraoperative and postoperative complications and statistical significance of difference was calculated.

**Results** There was no significant difference in terms of ROM, KOOS (Knee Injury and Osteoarthritis Outcome Score), (Knee Society Score) KSS, Eq. 5D, (Western Ontario and McMaster Universities Osteoarthritis Index) WOMAC, and (visual analog scale) VAS scores while we found significant difference in mechanical axis deviation, femoral and tibial implant alignment in both planes.

**Discussion** Advantages of using robotic TKA are customized preoperative planning, implants, cuts, accuracy of the intraoperative procedure, and radiological superiority with no significant differences in clinical and functional outcomes. In fact, robotic TKA is associated with steep learning curve, increased cost, and operative time. Still there are no added complications caused by it.

**Keywords**
- robotic
- conventional
- total knee arthroplasty
- mechanical axis deviation
- implant alignment
- femoral shaft

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## Introduction

Total knee arthroplasty (TKA) is most commonly performed procedure in patients who are not showing improvement in pain, functional limitations, activities of daily living, and quality of life by conservative modalities.[8] Precise component implantation and soft tissue management are required to achieve desired outcome following TKA.[1-7] 1.3% patients remain disappointed due to persistent pain, 24% due to instability, and 2.5% due to malalignment following TKA.[7-10] Conventional TKA makes use of mechanical jigs for precise bone cutting whereas robotic TKA is associated with the use of customized implants and bone cuts leading to precise component implantation and reduced deviation from mechanical axis in coronal, transverse, and sagittal plane and proper soft tissue management leading to theoretically superior radiological appearance and less complications[1-9,11] but at the cost of more surgical time, more expense, and chances of untoward complications.[1-9,11] This study aims at comparing conventional against robotic TKA in terms of clinical and functional outcome, implant alignment and inclination and postoperative complications.

## Materials and Methods

This prospective randomized control study was performed at Civil Hospital, Ahmedabad between January 2017 and December 2019 over a time span of 3 years. Ninety-two patients of osteoarthritis were enrolled in this study out of which 46 patients underwent robotic TKA while rest 46 patients underwent conventional TKA. Inclusion criteria for this study included the following: men and women between 35 and 85 years of age with symptomatic osteoarthritis of knee. Exclusion criteria for this study included the following: a body mass index (BMI) of >40 kg/m$^2$, recent history of knee injury; past history of infection of knee joint; past history of tibial or femoral shaft fracture; past history of tibial or femoral osteotomy; conversion of unicompartmental knee arthroplasty to TKA; neurological deficit involving the lower extremity; preoperative valgus malalignment of the knee; patients with American Society of Anaesthesiologists (ASA) category of >3; pre-existing hip pathology or previous hip replacement in same limb.[1-9,11] Demographic information like age, gender, etc. was collected. Patients were queried for any addictions and pre-existing comorbidities. All necessary examinations and investigations were performed. All patients underwent preoperative radiography (anteroposterior, lateral, long-leg views). A three-dimensional (3D) CT scan of the affected lower limb was done for patients undergoing robotic TKA. The 3D CT images were fed in ORTHODOC software which creates a 3D image of bone and determines the mechanical axis of patient. Best component type and size for the femur and tibia for each patient are determined; their implantation, alignment, and rotation were determined and this data was saved in a compact disk which is run in ROBODOC Surgical System (CUREXO's Artificial Joint Surgical Robot) prior to surgery. All the patients were informed regarding the procedure and their informed consents were taken. Patients were then prepared for surgery and anesthesia after their preanesthetic checkups. Medial parapatellar approach was used in both groups. Bone cuts were taken with the aid of mechanical zig in case of conventional TKA while robot aided bone cuts were taken in case of robotic TKA. Component implantation was done manually in both groups. Suction drain is kept and closure is done in a standard fashion. Operative time, intraoperative blood loss, and any intraoperative complications were noted .Postoperatively, both groups received the same medications. Active and passive knee mobilization exercises were started on postoperative day 1 along with partial weight bearing using a crutch or walker. Follow-up was done at 3, 6, and 12 months postoperatively. During each visit, clinical and functional evaluations were done along with radiograph. Clinical and functional evaluation was done using KOOS Score,[12] KSS (Knee Society Score),[13] EQ-5D (EuroQol-5 Dimensions),[14] WOMAC (Western Ontario and McMaster Universities Osteoarthritis Index),[15] VAS

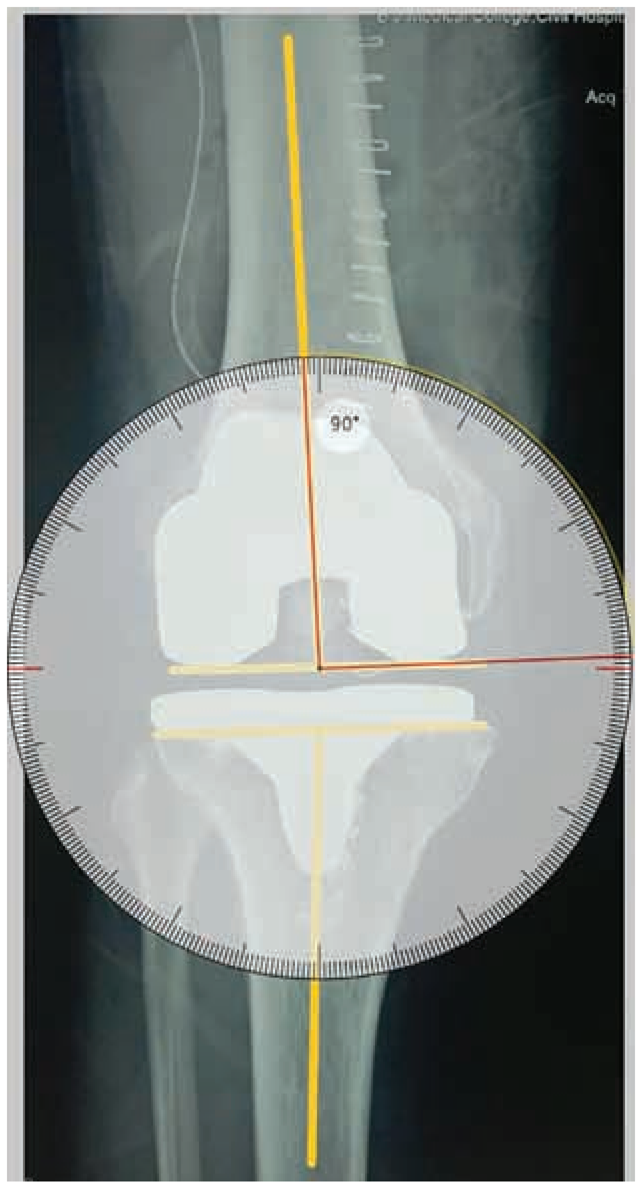


**Fig. 1** Coronal femoral implant inclination measurement.

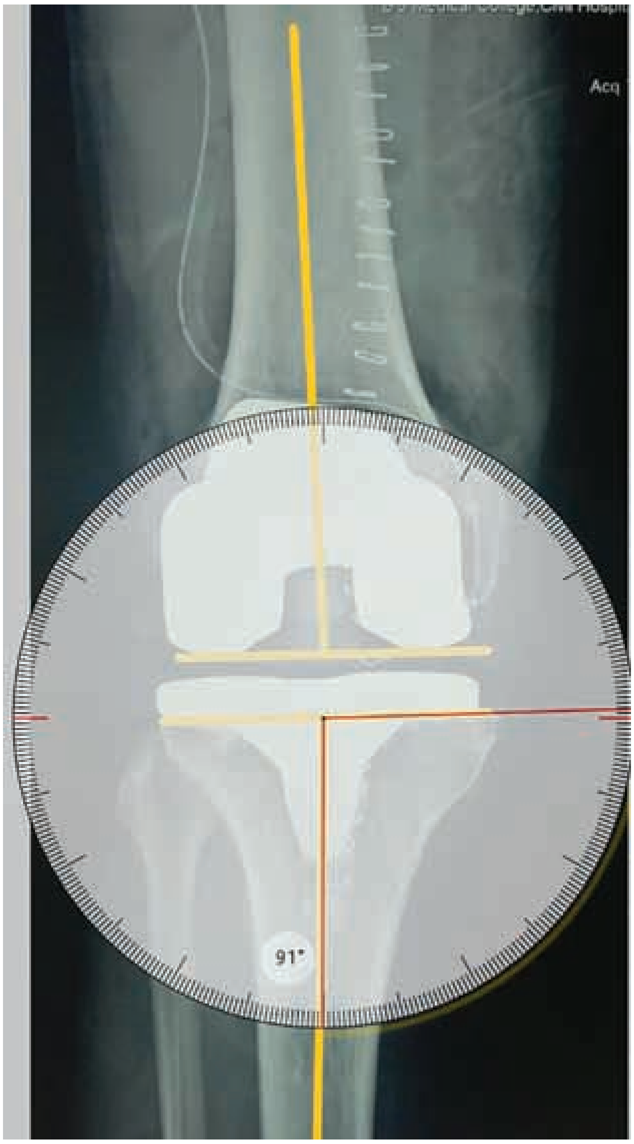


**Fig. 2** Coronal tibial implant inclination measurement.


**Fig. 3** Sagittal femoral implant inclination measurement.

(visual analog scale), and range of motion (ROM).[9] Radiological evaluation was done using mechanical axis deviation, femoral and tibial implant inclination in coronal (►**Figs. 1** and **2**) and sagittal plane (►**Figs. 3** and **4**) to check for malalignment and rotation of both components.[1-6] Results of both groups were compared using paired *t*-test and statistical significance of difference was measured. Significance was defined as *p*-value of <0.001. We used Microsoft Excel 2007 version software for all statistical analyses.

## Results

Ninety-two patients of osteoarthritis were enrolled in this study out of which 46 patients underwent robotic TKA while rest 46 patients underwent conventional TKA. The mean age of the patients in the robotic TKA group was 51.5 ± 8.9 years while in the conventional group was 48.6 ± 7 years. There were 39 females in the robotic TKA group and 24 females in the conventional group. There was no significant difference between the two groups in terms of baseline characteristics (►**Table 1**). There was significant difference in operative time ($p < 0.001$). As tourniquet was used for both groups there was no statistical difference in intraoperative blood loss in both the groups.

There was no significant difference in terms of KOOS score, KSS, Eq. 5D, WOMAC, and VAS scores in both groups (►**Table 2**).

There was no significant difference in terms of ROM in both groups (►**Table 3**) while we found significant difference in terms of mechanical axis deviation, femoral and tibial implant alignment in sagittal and coronal planes (►**Table 4**). Overstuffing of femur was seen in one case in conventional group and in no case in robotic group. Notching was not seen in any group. No patella replacement was done in any of the cases .There were no outliers (error >±3 degrees) in both the groups .Instability and fixed flexion deformity were not encountered in any of the cases of both groups.

Complications such as superficial or deep joint infections, deep vein thrombosis, prosthetic knee dislocation, periprosthetic fracture, or aseptic loosening were not encountered in this study.

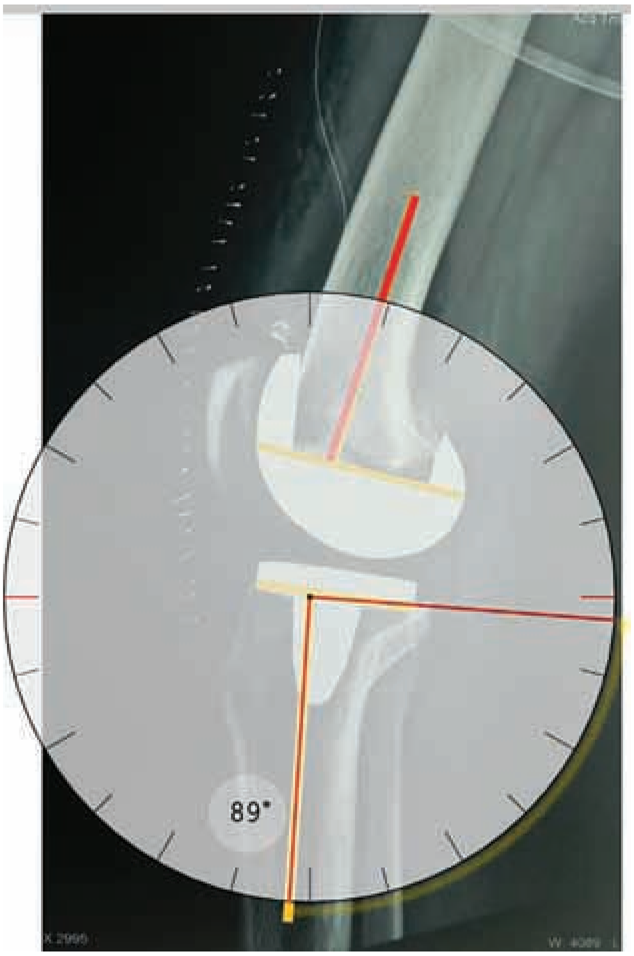


**Fig. 4** Sagittal tibial implant inclination measurement.

**Table 1** Demographic and intraoperative data

| | Conventional TKA (*n* = 46) | Robotic TKA (*n* = 46) |
|---|---|---|
| **Age** | 48.6 ± 7 | 51.5 ± 8.9 |
| **Gender (female)** | 39 (84.7%) | 24 (52.1%) |
| **Side (right)** | 28 (60.8%) | 28 (60.8%) |
| **Mean operative time** | 63.3 ± 5.2 | 114.6 ± 10.7 |

Abbreviation: TKA, total knee arthroplasty.

## Discussion

There was no significant difference in terms of baseline characteristics in both the groups. Also, there was no significant difference in terms of change in KOOS score, KSS, Eq. (5D), WOMAC, and VAS scores in both groups while there was significant difference in terms of mechanical axis deviation, femoral and tibial implant alignment in sagittal and coronal planes. Accurate implant alignment is essential for satisfactory clinical and functional outcome in patients as well as longevity of implant and its revision rate.[6,7] In conventional TKA femoral and tibial cuts are taken irrespective of patients anatomy whereas in case of robotic TKA it is customized based of patient's preoperative 3D CT scan leading to precise component implantation and reduced deviation from mechanical axis in coronal, transverse, and sagittal plane and reduces number of outliers leading to theoretically superior radiological appearance.[1-9,11] Femoral component is rotated and aligned with respect to transepicondylar axis in case of robotic TKA while in conventional TKA we use posterior condylar axis for the same which is less accurate which may lead to the difference in implantation and precision in both groups.[6,11] Milling tool which ranges from 0.15 to 0.29 mm[11,16] is used in robotic TKA while in conventional TKA it is done using an oscillating saw which ranges from 0.16 to 0.42 mm. In robotic TKA, the bone's temperature is maintained within the range of 45 to 48°C, by doing constant irrigation and controlled speed. Temperatures usually go beyond this range while using an oscillating saw in conventional TKA, resulting in potential bony injury and compromised implant fixation.[11,17,18] Thus all these factors lead to the reduction in mechanical axis deviation in robotic TKA as compared with conventional TKA. Despite of difference in terms of radiological parameters there is no difference in clinical outcome in both groups which proves that despite radiological superiority and implant ion accuracy patient's clinical and functional results are same in both groups at 1 year follow-up.

There were no outliers (±3 degrees) in this study. Gromov et al suggested that outliers are associated with patient dissatisfaction, poor biomechanics, ROM, reduced implant longevity, and increased revision rates[19]; however, study conducted by Petursson et al suggested that even outliers are associated with similar results.[9]

**Table 2** Clinical outcome in conventional versus robotic TKA group

| | Conventional TKA (*n* = 46) | | Robotic TKA (*n* = 46) | | |
|---|---|---|---|---|---|
| | Pre-op | Post-op | Pre-op | Post-op | *p*-Value |
| KOOS | 46.5 ± 3.7 | 87.3 ± 4.2 | 47.1 ± 3.8 | 87.3 ± 3.6 | 0.91 |
| KSS | 47 ± 4.5 | 87.2 ± 3.8 | 45.3 ± 5.9 | 86.8 ± 3.6 | 0.55 |
| Eq. 5D | 46.8 ± 3.5 | 87.5 ± 3.6 | 46.3 ± 5.9 | 86.7 ± 3.6 | 0.31 |
| WOMAC | 79 ± 5.2 | 25 ± 3.4 | 79.2 ± 5.5 | 24.7 ± 3.1 | 0.65 |
| VAS | 7.5 ± 2.7 | 2.2 ± 0.8 | 7.1 ± 3.1 | 2.2 ± 1.6 | 0.81 |

Abbreviations: KOOS, Knee Injury and Osteoarthritis Outcome Score; KSS, Knee Society Score; WOMAC, Western Ontario and McMaster Universities Osteoarthritis Index; VAS, visual analog scale.

**Table 3** Functional outcome in conventional versus robotic TKA group

| | | Conventional TKA (*n* = 46) | | Robotic TKA (*n* = 46) | | |
|---|---|---|---|---|---|---|
| | | Pre-op | Post-op | Pre-op | Post-op | *p*-Value |
| ROM | Flexion | 114 ± 9.6 | 127.5 ± 5 | 112.7 ± 9.6 | 127.1 ± 5.1 | 0.7 |
| | Extension | 6.2 ± 2.2 | 2 ± 1.3 | 5.9 ± 2.6 | 1.1 ± 1 | <0.001 |
| Mechanical axis deviation | | 6.4 ± 1.5 | 1.1 ± 0.7 | 6.4 ± 1.5 | 0.5 ± 0.6 | <0.001 |

Abbreviations: ROM, range of motion; TKA, total knee arthroplasty.

**Table 4** Radiological outcome in conventional versus robotic TKA group

| | | Conventional TKA (*n* = 46) | Robotic TKA (*n* = 46) | *p*-Value |
|---|---|---|---|---|
| Femoral implant inclination | Sagittal plane | 1.1 ± 0.7 | 0.5 ± 0.6 | <0.001 |
| | Coronal plane | 88.4 ± 1.2 | 89.9 ± 0.2 | <0.001 |
| Tibial Implant Inclination | Sagittal plane | 87.3 ± 1.9 | 88.6 ± 1.2 | <0.001 |
| | Coronal plane | 90.8 ± 0.6 | 90.2 ± 0.4 | <0.001 |

Robotic TKA is associated with longer operative time (mean operative time 114.3 minutes) compared with conventional TKA which may be attributed to longer learning curve and planning time. Despite of longer operative time robotic TKA was not associated with any complications related to longer operative time such as infection, increased blood loss, and other such complications. A total of 127 minutes is considered as a critical time after which there is increased risk of infection as suggested by Peersman et al.[6,8,20]Complications such as superficial or deep joint infections, deep vein thrombosis, prosthetic knee dislocation, periprosthetic fracture or aseptic loosening were not encountered in this study.

Drawback of using robotic TKA is that it is associated with increased operative time, increased cost, steep learning curve, need for preoperative CT scan, and chances of untoward complications.[11]

There are severe limitations of this study that need attention prior to interpreting the findings. Sample size was too small. Follow-up period is 1 year in this study. Long-term follow-up (>5 years) of clinical and functional outcome as well as of complications is required to be done to check for long-term efficacy. Patients and observers could not be blinded as patients in the robotic group had an additional incision over the proximal tibia for the insertion of the registration pins. Preoperative grading of the arthritis was not done in this study. Postoperative radiological parameter calculation was done using radiographs. Accurate calculation could have been possible by using CT-scan images.

## Conclusion

Robotic TKA is associated with precise component implantation, alignment, and reduced aberration from mechanical axis leading to radiological superiority over its conventional counterpart. However, despite of such radiological superiority there is no significant differences in clinical and functional outcomes when compared with conventional TKA. In fact, robotic TKA is associated with increased cost, steep learning curve, and increased operative time. Though robotic TKA is associated with increased operative time there is no added complications caused by it. Hence there is no disadvantage of using a robot for performing TKA. Also there is no overall added advantage of using a robot and adding to the expense of the patient.

**Note**

Informed consent has been taken from all individual participants included in the study. The local Ethics Committee of University has confirmed that no ethical approval is required.

**Funding**

None.

**Conflict of Interest**

None declared.

## References

1 Moon YW, Ha CW, Do KH, et al. Comparison of robot-assisted and conventional total knee arthroplasty: a controlled cadaver study using multiparameter quantitative three-dimensional CT assessment of alignment. Comput Aided Surg 2012;17(2):86–95
2 Ofa SA, Ross BJ, Flick TR, Patel AH, Sherman WF. Robotic total knee arthroplasty vs conventional total knee arthroplasty: a nationwide database study. Arthroplast Today 2020;6(4):1001–1008.e3
3 Kayani B, Konan S, Tahmassebi J, Pietrzak JRT, 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(7):930–937
4 Bhimani SJ, Bhimani R, Smith A, Eccles C, Smith L, Malkani A. Robotic-assisted total knee arthroplasty demonstrates decreased postoperative pain and opioid usage compared to conventional total knee arthroplasty. Bone Jt Open 2020;1(2):8–12

5 Ren Y, Cao S, Wu J, Weng X, Feng B. Efficacy and reliability of active robotic-assisted total knee arthroplasty compared with conventional total knee arthroplasty: a systematic review and meta-analysis. Postgrad Med J 2019;95(1121):125–133
6 Song EK, Seon JK, Yim JH, Netravali NA, Bargar WL. Robotic-assisted TKA reduces postoperative alignment outliers and improves gap balance compared to conventional TKA. Clin Orthop Relat Res 2013;471(1):118–126
7 Chin BZ, Tan SS, Chua KCX, Budiono GR, Syn NL, O'Neill GK. Robot-assisted versus conventional total and unicompartmental knee arthroplasty: a meta-analysis of radiological and functional outcomes. J Knee Surg 2020;(e-pub ahead of print). doi: 10.1055/s-0040-1701440
8 Mancino F, Cacciola G, Malahias MA, et al. What are the benefits of robotic-assisted total knee arthroplasty over conventional manual total knee arthroplasty? A systematic review of comparative studies. Orthop Rev (Pavia 2020;12(suppl 1) :8657
9 Petursson G, Fenstad AM, Gøthesen Ø, et al. Computer-assisted compared with conventional total knee replacement: a multicenter parallel-group randomized controlled trial. J Bone Joint Surg Am 2018;100(15):1265–1274
10 Pitta M, Esposito CI, Li Z, Lee YY, Wright TM, Padgett DE. Failure after modern total knee arthroplasty: a prospective study of 18,065 knees. J Arthroplasty 2018;33(2):407–414
11 Liow MH, Chin PL, Tay KJ, Chia SL, Lo NN, Yeo SJ. Early experiences with robot-assisted total knee arthroplasty using the DigiMatch™ ROBODOC® surgical system. Singapore Med J 2014;55(10):529–534
12 Roos EM, Roos HP, Lohmander LS, Ekdahl C, Beynnon BD. Knee Injury and Osteoarthritis Outcome Score (KOOS)—development of a self-administered outcome measure. J Orthop Sports PhysTher 1998;28(2):88–96
13 Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. Clin Orthop Relat Res 1989;(248):13–14
14 EuroQol Group. EuroQol—a new facility for the measurement of health-related quality of life. Health Policy 1990;16(3):199–208
15 Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol 1988;15(12):1833–1840
16 Bellemans J, Vandenneucker H, Vanlauwe J. Robot-assisted total knee arthroplasty. Clin Orthop Relat Res 2007;464(464):111–116
17 Denis K, Van Ham G, Vander Sloten J, et al. Influence of bone milling parameters on the temperature rise, milling forces and surface flatness in view of robot-assisted total knee arthroplasty. Int Congr Ser 2001;1230:300–306
18 Eriksson RA, Albrektsson T. The effect of heat on bone regeneration: an experimental study in the rabbit using the bone growth chamber. J Oral Maxillofac Surg 1984;42(11):705–711
19 Gromov K, Korchi M, Thomsen MG, Husted H, Troelsen A. What is the optimal alignment of the tibial and femoral components in knee arthroplasty? Acta Orthop 2014;85(5):480–487
20 Peersman G, Laskin R, Davis J, Peterson MG, Richart T. Prolonged operative time correlates with increased infection rate after total knee arthroplasty. HSS J 2006;2(1):70–72

 