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Original Research Article

Knee replacement surgery is more precise with "*Robotic Technology*"- Is it true?

Hrushikesh Saraf[1], Shreepal Munot[1,*]

[1] *Dept. of Orthopaedics, Shashwat Hospital, Pune, Maharashtra, India*

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ABSTRACT

Background: Robotic assisted total knee arthroplasty is one the recent advance to improve its outcome especially to address the issue of precision. Longetivity of TKA primarily depends on proper implant alignment. The Aim of this study is to compare the precision of robotic assisted TKA with the ideally planned mechanical parameters in TKA.

Materials and Methods: A total of 50 robotic assisted TKA patients were included retrospectively in the study. Patient's post operative mechanical femorotibial angle (mFTA), Lateral distal femoral angle (LDFA), medial proximal tibial angle (mPTA) in AP radiogram.and anterior femoral offset ratio, posterior condylar offset ratio, femoral component flexion, posterior tibial slope in lateral radiograms were evaluated with ideal values for specific parameter. Number of outliers were counted separately with values beyond 3^0 of malalignment.

Results: The mean postoperative FTA, LDFA, mPTA recorded is 0.15 ±0.70, 89.78±0.79, 89.80±0.86 respectively. The mean postoperative posterior tibial slope, femoral flexion is 3.03±0.35, 3.14±0.60 respectively. All the parameters when compared with planned ideal values (i.e. mFTA= 0^0, mPTA=90^0, LDFA=90^0, Posterior tibial slope=3^0, femoral component flexion=3^0) did not show significant difference.

Conclusion: Study shows promising results with near normal execution of planned TKA. Robotic assisted TKA can be a game changer and a handy tool to improve the alignment of mechanical axis in TKAs.

1. Introduction

Total knee arthroplasty (TKA) is one of the very successful and widely done surgery. Since osteoarthritis becomes more severe with growing age, number of TKA surgeries is on the rise and main reason behind the growing number is the increase in life expectancy globally.[1] The number of TKA performed in the last two decades has increased with 162%.[2]

With every passing year, there has been lot of research on different aspect of TKA like functional outcomes, implant material, implant design, knee dynamics, knee alignment. But since early days and until now orthopaedic community is very much interested in increasing the longetivity of TKA. Many crucial factors have been studied for longetivity including implant chemistry, design, cementing technique, post-operative knee alignment either kinematic or mechanical.[3]

Post operative knee alignment can be a major factor that can decide long term survivorship of TKA. Today it is widely accepted that a précised and well aligned TKA will definitely last longer than poorly aligned TKA that leads to shorter life span of implant.[4,5]

2. Materials and Methods

A total of 50 patients reviewed retrospectively who were operated between august 2018 to August 2019. Informed

* *Corresponding author*.
E-mail address: drshreepalmunot@gmail.com (S. Munot).

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consent were obtained from all the patients before their inclusion in this study.

Inclusion criteria was patients requiring primary TKA using robotic assisted system. Same prosthesis (smith and nephew anthem CR/PS) were used in all the cases. Exclusion criteria were TKA due to secondary osteoarthritis, hemophilic arthroplasty, infection, ankylosed knee. Knee flexion range < 90^0, varus > 25^0, FFD > 30^0 excluded which can skew the study.

All surgeries were done by same surgeon at same center using robotic assisted system (navio -smith and nephew).

2.1. Steps of robotic assisted TKA

1. Approach-anterior midline incision, medial parapatellar arthrotomy used in all cases.
2. Bone tracker and Checkpoint placement- Two rigid schanz pins are put in femur and tibia. Pins are connected with bicortical fixation system, tracker clamps and sensors. Camera is oriented to visualize both the trackers throughout the range of motion. Checkpoint pins are put on medial femoral metaphysis and antero-medial surface of proximal tibia. These points are referred using point probe at defined stages throughout the procedure to determine if either tracker array has moved.
3. Registration- Mechanical axis is calculated by defining ankle center, knee center, hip center.
4. Surface mapping-free points collected over distal femur including anterior cortex, posterior condyles, medial/lateral surface. Similarly free tibial points collected over the articular surface including medial and lateral edges, anterior cortex.(Figure 1 A,B)
5. Gap planning -Cuts are planned to achieve balanced medial-lateral graph in flexion and extension. Femur and tibia implants can be shifted proximally or distally, can be rotated internally and externally and can be put in varus/valgus to achieve the planned alignment. Femur implant flexion and tibia implant slope can also be altered if necessary.(Figure 1 C)
6. Bone preparation- once planning is complete, bone cuts can be taken using burr all, distal burring for femur and all burr for tibia in speed or exposure control mode (author prefer distal burring method to preserve rest of the bone cuts in case required as bone graft). Cuts can be rechecked with digital umbrella and fine changes can be done using all burr technique. (Figure 1 D,E,F,G)

After preparation of femur and tibia, trial can be put and checked for FFD, coronal deformities, range of motion, instability in post op gap assessment screen.(Figure 1 H) Fine changes can be done at this stage as well to achieve satisfactory alignment.

Post op standing AP (including hip, knee, ankle) and lateral radiogram taken at 3 weeks.

Fig. 1: A: Free femur point collection with probe; **B:** Free Tibia point collection with probe; **C:** Gap planning to achieve balanced graph medio-laterally in flexion and extension; **D:** Femur distal cut with burr; **E,F:** Checking of femur cuts with digital umbrella after planned cuts; **G:** Checking of tibial cut after planned cut; **H:** post trial implant gap assessment. It should be within 2mm tightness or laxity

2.2. Measurements

Preoperative and postoperative standing AP radiogram including hip, knee, ankle and Lateral radiogram were evaluated to measure mechanical femoral-tibial angle (mFTA), Lateral distal femoral angle (LDFA), medial proximal tibial angle (mPTA) in AP radiogram and anterior femoral offset ratio, posterior condylar offset ratio, femoral component flexion, posterior tibial slope in lateral radiograms. Postoperative alignment values compared with the planned values (i.e. mFTA= 0^0, mPTA=90^0, LDFA=90^0, Posterior tibial slope=3^0, femoral component flexion=3^0) using one sample t-test.

3. Results

-Total of 50 patients included in the study. Mean age of the patient is 70.2±5.2 years. 27 patients were female and 23 patients were male. Mean preoperative mFTA was 10.2 ±3.2 post operative mFTA was 0.15 ±0.70. Other variables are shown in Table 1. Few examples are shown in Figures 2 and 3.

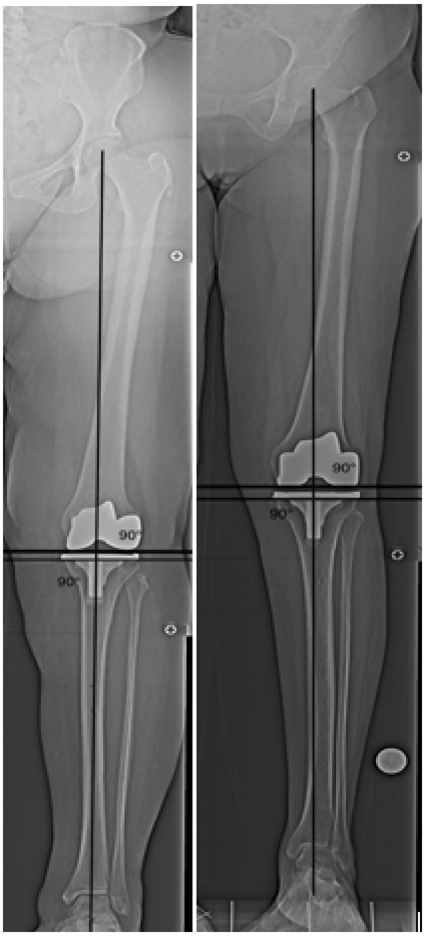

Fig. 2: AP standing hip, knee, ankle radiogram - mFTA-0^0, mPTA-90^0, LDFA-90^0

Out of 50 patients 36 patients (72%) have 0^0 post-operative mFTA. 30 patients (60%) have 90^0 mPTA, 32 (64%) patients have 90^0 LDFA. 40 patients (80%) have planned posterior slope of 3^0.38(76%) patients have planned flexion of 3^0.40 (80%) patients have posterior condylar offset ratio< 95%, 42 (84%) patients have anterior femoral offset ratio < 15%. 44 patients (88%) have femoral implant flush with anterior cortex. Alignment beyond 3^0 of neutral values were recorded separately and labeled as outliers.(Table 2)

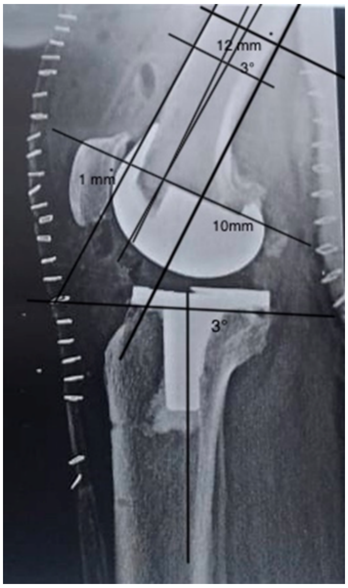

Fig. 3: Lateral radiogram-tibial posterior slope-3^0, femur component flexion -3^0, Posterior condylar offset ratio-83.33, Anterior femoral offset ratio-8.33, femur component is flushed anteriorly

4. Discussion

One of the basic requirements to achieve well aligned knee in TKA is to restore mechanical neutral axis of the lower limb. Ideally intraoperative correction of limb alignment should be within 0^0 $\pm 3^0$ of mechanical axis.[6] Studies by Ritter et al[7] and by fang et al[8]in 6070 TKA with mean follow up of 8 years showed increased rate of failure with post-operative varus malalignment of anatomical tibiofemoral axis(TFA) < $2.5^0$and valgus malalignment (TFA > 7.5^0). Similar results were seen in study by Kim et al[9] in which he demonstrated increased failure rate in post operative varus malaligned knee (TFA<3^0) compared to neutrally aligned knee (TFA3^0-7.5^0). In our study we are able to achieve mFTA of 0.15 ±0.7 with only 4% outliers using robotic assisted system.

It is equally important to achieve neutral alignment of knee by optimal placement of femoral component and tibial component rather than compensating varus/valgus alignment of one component with other.

Femoral component coronal alignment should be within $\pm 2^0$ of femoral mechanical axis(FMA). A study by longstaff et al[10] reported that patients with neutral femoral alignment ($\pm 2^0$ of FMA) had better KSS scores at 1 year follow up. Similarly tibial component should be put in $90^0$to the mechanical axis.[11] Tibial malalignment of >$3^0$of varus has been reported to increase the risk of medial bone collapse.[12] In the current study achieved LDFA is 89.78±0.79 and mPTA is 89.80±0.86 which is almost neutral with fewer outliers (LDFA-6%, mPTA-4%).

Table 1: Radiographic measurement in patients operated with robotic assisted TKA

Variables	Observed values (n=50)	Planned values	P
1) Coronal measurement			
mFTA	0.15 ±0.70	0	P=0.1361
mPTA	89.80±0.86	90	P=0.1065
LDFA	89.78±0.79	90	P=0.1316
2) Sagittal measurement			
Posterior tibial slope	3.03±0.35	3	P=0.5473
Femoral component flexion	3.14±0.60	3	P=0.1054
Posterior condylar offset ratio	93.06±2.93	<95	-
Anterior femoral offset ratio	13.54±4.22	<15	-
% of femoral component flush anteriorly	84%	-	-

mFTA-mechanical femorotibial angle, mPTA-medial proximal tibial angle, LDFA-lateral distal femoral angle

Table 2: Outliers (±> $3^0$from neutral)

mFTA	2 (4%)
LDFA	3 (6%)
mPTA	2 (4%)

Sagittal alignment of femoral and tibial component is also important for implant survival, stability, and flexion gap and post operative flexion. Kim et al. showed 3.3% failure rate in knees with femoral implant flexed > 3^0 compared to failure rate of 0% and 0.9% in neutrally aligned femoral component (0^0-3^0 flexion) and extended femoral component (>1^0 extension) respectively. In the same study it was found that tibial malalignment in the sagittal plane (<0^0 or >7^0) had failure rate of 4.5% as compared to a failure rate of 0.2% in the neutrally aligned group.[9] In our study planned femoral flexion is 3^0 and tibial slope is also 3^0 (another 3^0 slope within implant). Achieved femoral prosthesis flexion is 3.03±0.35 and achieved tibial slope is 3.14±0.60.

Technology plays an important role in execution of planned surgery. Options like computer navigation, robotic assisted TKA increase the precision to near normal. In this current study we used navio system based on robotic arm assisted technology in which cuts can be planned, executed, rechecked and if required again corrected to the desired planned cuts. Even 1^0 or 1mm of correction can be done precisely using this technology. A recent study by casper M et al. who studied accuracy of handheld robot system for TKA in 18 cadavers concluded that absolute mean tibial and femoral error were within 1 mm of neutral.[13] In a comparative study by Bollars P to study implant alignment and outliers in navio TKA group with conventional TKA group, they demonstrated lower rate mechanical axis outliers in navio TKA group (6% vs 18%) P=0.051). Navio TKA group had significantly reduced rate of outliers in the frontal tibial component (0% vs 8% P= 0.038) and improved post operative mechanical axis (180.1 vs 179.1 P=0.028) compared to conventional TKA group.[14]

5. Conclusion

Robotic TKA not only allow the surgeon to plan the TKA cuts precisely but also help in execution, rechecking, refining, reproducing same results with minimal error to achieve the planned mechanical axis of the limb. Robotic TKA definitely hold the key in future for the successful and precise implementation of TKA.

6. Source of Funding

None.

7. Conflict of Interest

The authors declare no conflict of interest.

References

1. Iorio R, Robb WJ, Healy WL. Orthopaedic surgeon workforce and volume assessment for total hip and knee replacement in the United States: preparing for an epidemic. *J Bone Joint Surg Am*. 2008;90(7):1598–1605.
2. Cram P, Lu X, Kates SL, Singh JA, Li Y, Wolf BR. Total knee arthroplasty volume, utilization, and outcomes among Medicare benefi ciaries, 1991-2010. *JAMA*. 1991;12:1227–36.
3. Becker R, Hirschmann MT, Karlsson J. Does implant design and surgical technique improve the clinical outcome in total knee arthroplasty? *Knee Surg Sports Traumatol Arthrosc*. 2014;22(8):1716–8.
4. Lombardi AV, Berend KR, Ng VY, Ng VY. Neutral mechanical alignment: a requirement for successful TKA: affirms. *Orthopedics*. 2009;34(9):504–6.
5. Parratte S, Pagnano MW, Trousdale RT, Berry DJ. Effect of postoperative mechanical axis alignment on the fifteen-year survival of modern, cemented total knee replacements. *J Bone Joint Surg Am*. 2010;92(12):2143–9.
6. Gromov K, Korchi M, Thomsen MG. What is the optimal alignment of the tibial and femoral components in knee arthroplasty? *Acta Orthop*. 2014;85:480–7.
7. Ritter MA, Davis KE, Meding JB, Pierson JL, Berend ME, Malinzak RA. The effect of alignment and BMI on failure of total knee

replacement. *J Bone Joint Surg (Am)*. 2011;93(17):1588–96.

8. Fang DM, Ritter MA, Davis KE. Coronal alignment in total knee arthroplasty. *J Arthroplasty*. 2009;24(6):39–43.
9. Kim YH, Park JW, Kim JS, Park SD. The relationship between the survival of total knee arthroplasty and postoperative coronal, sagittal and rotational alignment of knee prosthesis. *Int Orthop*. 2014;38(2):379–85.
10. Longstaff LM, Sloan K, Stamp N, Scaddan M, Beaver R. Good alignment after total knee arthroplasty leads to faster rehabilitation and better function. *J Arthroplasty*. 2009;24(4):570–8.
11. Ritter MA, Herbst SA, Keating EM, Faris PM, Meding JB. Patellofemoral complications following total knee arthroplasty. Effect of a lateral release and sacrifice of the superior lateral geniculate artery. *J Arthroplasty*. 1996;11(4):368–72.
12. Berend ME, Ritter MA, Meding JB, Faris PM, Keating EM, Redelman R. Tibial component failure mechanisms in total knee arthroplasty. *Clin Orthop*. 2004;428:26–34.
13. Casper M, Mitra R, Khare R, Jaramaz B, Hamlin B. Accuracy assessment of a novel image-free handheld robot for Total Knee Arthroplasty in a cadaveric study. *Comput Assist Surg (Abingdon)*. 2018;23(1):14–20. doi:10.1080/24699322.2018.1519038.
14. Bollars P, Boeckxstaens A, Mievis J, Kalaai S, Schotanus MGM, Janssen D. Preliminary experience with an image-free handheld robot for total knee arthroplasty: 77 cases compared with a matched control group. *Eur J Orthop Surg Traumatol*. 2020;30:723–9.

Author biography

Hrushikesh Saraf, Orthopaedic Surgeon

Shreepal Munot, Orthopaedic Surgeon

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