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Original Research Article

Increasing range of motion in total knee replacement using novel patellar resection technique

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ABSTRACT

Background: Total knee arthroplasty (TKA) is a surgical procedure designed to alleviate pain and improve function in patients suffering from osteoarthritis. Range of motion is one of the most important factors for patient satisfaction after total knee replacement. The purpose of this study was to assess the effectiveness of a new TKA technique involving patellar resection to enable increased flexion of the knee joint.

Methods: Eighty-four patients suffering from osteoarthritis with an indication for conducting TKA underwent the novel procedure. Pre-operative and post-operative flexion measurements were assessed.

Results: Mean age of patients participating in this study was 62 years. Males and females were 63% and 37 % of total population respectively. The mean pre-operative and post-operative flexion measurements were 97.39±3.33 º and 131.35±4.27 respectively. The mean in flexion measurements was improved by 33.95±5.30 º ($p<0.05$). The joint was kinematically stable during full flexion, mid-flexion, and extension.

Conclusions: The novel patellar resection technique can be beneficial for the patients. They can able to follow their native lifestyle and perform their daily activities without any hindrance. The mean increase in the range of flexion was 33.95±5.30 º (ranged 30-35 º, $p<0.05$). This technique allowed patients to have a greater range of flexion as compared to standard and high flexion designs.

Keywords: TKA, Osteoarthritis, Range of motion, Flexion, Patellar resection, Pressed fit condylar

INTRODUCTION

Osteoarthritis is the most common cause of articular disease and one of the leading causes of chronic disability in the world.[1] Knee osteoarthritis is associated with huge economic costs and reduced quality of life.[2] Total knee arthroplasty (TKA), a surgical procedure, is designed to improve functions and alleviate pain in patients suffering from knee osteoarthritis or rheumatoid arthritis.[3]

However, functional performance after TKA is lower as compared to healthy adults. Patients often complain of slower walking or stair climbing speed, difficulty in doing activities that require flexion of the knee joint and reduced muscle strength.[4] Patients having marked functional limitations, low mental health scores, comorbid conditions, and severe pain have even worse postoperative outcomes.[5] In India, people often sit cross-legged or on lower couches which require deep knee flexion. In rural areas, many daily activities including cooking are performed in squatting positions. The daily prayer or 'Salat', which average Muslim practices on the floor five times a day requires standing, bowing, sitting and prostration. Also, Indians usually use hole toilets for which a full deep squat is required. Hence procedures which enable higher flexion are preferred in India.[6]

High flex posterior cruciate substituting polyethylene tibial inserts, legacy PS-flex fixed bearing PS TKA and Nexgen CR-Flex fixed bearing posterior cruciate-retaining TKA are some of the high flexion techniques which have been employed to date.[7,8] However, extensive bone resection is involved in these techniques. This leads to the femoral compartment loosening a phenomenon that leads to early revisions. These complications lead to considerable morbidity and mortality.[9] Mai et al conducted a study to assess flexion after TKA using five prostheses (two standard and three high flexions). A total of 108 patients took part in the study. They underwent 144 TKAs. Mean post-operative flexion was 111º for standard designs and 114º for high-flexion designs. Passive flexion was added to enhance flexion. This increased the postoperative flexion to 115º for standard designs and 119º for high flexion designs.[10] Guild et al published a study in which 23 patients were randomized to receive either NexGen LPS standard or high flexion prosthesis. 24 TKAs were performed and followed up for a duration of 2 years. The mean pre-operative flexion measurements were 113 and 102º in the Nexgen LPS and Nexgen LPS Flex groups respectively. At the 2 year follow-up, the mean post-operative flexion values were 113 and 106.2º in the Nexgen LPS and Nexgen LPS Flex groups respectively.[11] McCalden et al compared the ranges of motion provided by Genesis II posterior stabilized insert and Genesis II high flex insert in 100 patients who were randomized to receive either of the two implants.[7] Another study consisted of fifty-three patients who underwent TKA using Genesis II posterior stabilized prosthesis with high flex insert. In this study authored by Ohno H et al and published in 2016 patients were followed up for a mean duration of 76 months. It was observed that the pre-operative flexion range improved from 112-123º post-operatively. It was also found that although 39% of the patients enjoyed a floor-sitting life prior to the intervention, only 30% of the patients enjoyed it post-operatively.[12] Evidence suggests that there is need for a procedure especially taking into consideration the needs of the Indian population which will enable greater flexion. Also, this technique must avoid bone resection which is usually involved in high flexion designs. This will reduce complications such as loosening of the femoral compartment and early revisions.

Bengs et al and Abolghasemian et al in their respective studies have shown an inverse correlation between patellar thickness and knee flexion.[13,14] Hence, the author has devised a novel technique involving partial patellar resection which enables deep knee flexion in TKA patients whilst using the standard press fit condylar sigma implant. The resection of 3 mm of the patella in this technique leads to generation of extra volume of space which enables deeper knee flexion. Also, it reduces the patellofemoral contact forces thus reducing discomfort and facilitating flexion of the knee joint. The author decided to conduct this study to assess the effectiveness of this technique.

METHODS

Inclusion criteria

In this planned interventional study patients suffering from osteoarthritis with an indication for TKA from January 2011 until December 2013 from 2 institutes (Shri R.B. Shah Mahavir Superspeciality Hospital and Nirmal Hospital, Surat) were enrolled. The mean pre-flexion of incorporated patients was between 95-105º.

The rationale behind the technique

Anatomically, the patella is thinner at its superior aspect and thicker at the inferior aspect (Figure 1).

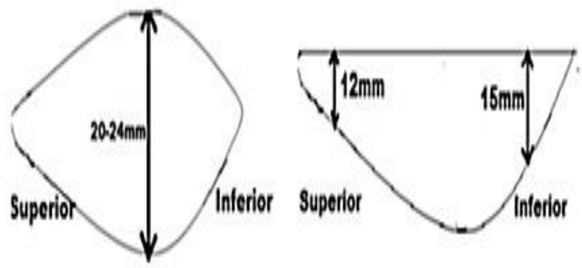

Figure 1: Patella at superior and inferior aspect.

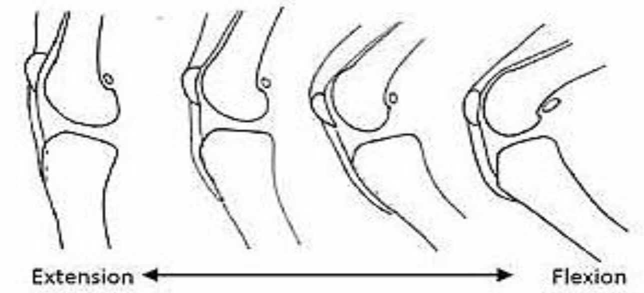

Figure 2: Patellar position from full extension to flexion.

The principle by which this technique helps in accommodating deep knee flexion lies in understanding the position of the patella at different flexion angles and role of the patella in changing the lever arm. When the knee is in full extension, the distal portion of patella articulates with the femur. As the knee goes from full extension to flexion the articular surface shifts towards proximal surface of the patella (Figure 2).

In deep knee flexion the articular surface is the proximal-most aspect of the patella. Resection of an extra 3 mm from the superior aspect of patella, leads to the generation of extra volume of space which enables smoother deep knee flexion. Moreover, this also increases the lever arm of quadriceps which eventually aids in deep knee bending. This resection enables a significant reduction in the patella-femoral contact forces which indirectly comforts the patient in deep knee flexion.

Procedure

This was an interventional study conducted at 2 institutes, Shri R. B. Shah Mahavir Superspeciality Hospital and Nirmal Hospital, Surat, India from January 2011 until December 2013. A total of 84 patients were recruited. The degree of flexion for each patient was assessed pre-operatively. The same novel patellar resection technique was employed in all the patients. The patients were implanted with the fixed bearing pressed fit condylar (PFC) sigma joint. Computer navigation (Ci Brainlab) was used for the surgeries along with SP2 instrumentation set of Depuy Pvt. Ltd. All the surgeries were performed under tourniquet. The standard medial parapatellar approach was employed in which the patella is everted laterally to expose the entire tibio-femoral joint. The femoral and tibial morphing was performed with the help of computer navigation. The data points obtained during the morphing were used to obtain the correct implant size and the level of femoral and tibial resection. Distal femoral resection of 9 mm was performed keeping valgus angle in between 5-7º in accordance with computer navigation. Similarly, tibial resection of 8-10 mm was performed adjusting the tibial slope to 3º. The femoral and tibial cuts were verified with the help of navigation paddle. The knee was placed in full extension and with the help of laminar spreader and spacer blocks and the extension gap was verified for its rectangularity. The anterior and posterior cuts were then performed with the aid of computer navigation using jigs. Flexion-extension gap symmetry was verified before proceeding with final implantation. The flexion angle and/or A-P shift was performed in the navigation to obtain flexion-extension gap symmetry. This was followed by chamfer and notch cuts with respective size of zigs. Trial implant was put and checked for flexion-extension symmetry. All prostheses were fixed with cement.

After tibial and femoral preparation is completed, depending on the thickness of the patella, the patella resection guide was adjusted. The patella was held laterally and the resection was performed. In all the cases initially 5 mm of the surface was shaved. Following this, the guide was removed and in the everted position, the patella was held with clamps and an additional 3 mm of the superior part of patella was resected. To avoid over resection of the patella a minimum of 12 mm was left proximally. The difference between the thickness of superior and inferior facet was of 3 mm. This additional resection of 3 mm accommodates and provides space for the movement of the femoral component in deep knee bending (Figure 3).

Intraoperative and postoperative pain management protocols for all the patients were identical. Combined epidural and oral analgesia were used for pain management. All patients were given continuous passive motion (CPM) of 0-100º on the 1st postoperative day. On 2nd day the patients were given 0-120º CPM and were encouraged to do knee bending at the edge of the cot in high sitting position. All the patients were mobilized from the 1st post-operative day itself. Postoperative flexion was measured. All the study assessments were made by an orthopedic surgeon.

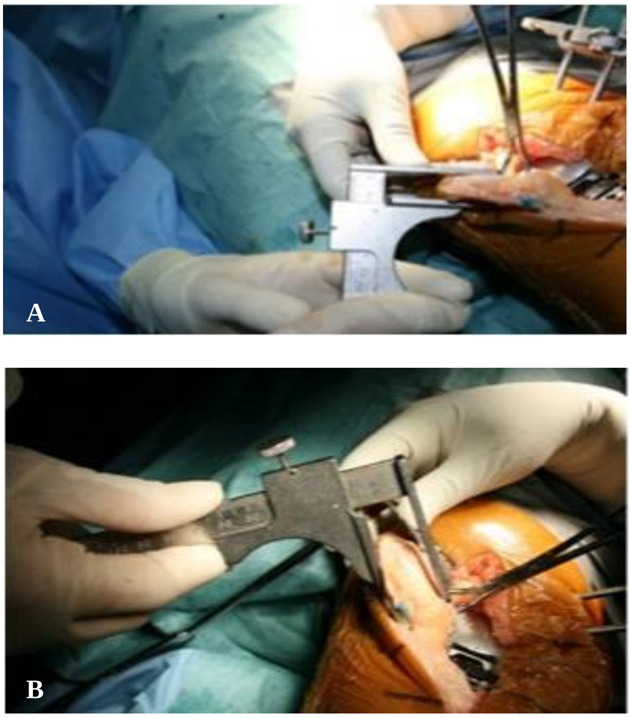

Figure 3 (A & B): Novel patellar resection technique.

Data-analysis

For each patient pre-operative and post-operative flexion values were entered in a pre-determined excel sheet. Mean values of pre-operative and post-operative flexion was calculated and Student's t-test at 95% confidence interval was used to compare the means.

RESULTS

Patients participated in this study were from the age group of 52-74 years. The mean age of presentation was 62 years. In this study 63% were males, 37% were females. The mean value of pre-operative flexion was 97.39±3.33 º (ranging from 95 to 105 º). It was compared with the mean value of post-operative flexion 131.35±4.27 º (ranging from 125 to 135 º) (Table 1). The mean increase in the flexion was 33.95±5.30 º (ranged 30-35 º) after treating with the modified technique and this value was statistically significant ($p<0.05$). The patients were asked to perform deep knee bending. Their performance was satisfactory as certified by the assessing orthopedic surgeon. The operated knee joint in all patients was kinematically stable in full extension, mid flexion and full flexion.

Table 1: Comparison of pre-operative flexion with post-operative flexion.

Descriptive statistics	Pre-op flexion (in °)	Post op flexion (in °)	Superior patella thickness (in mm)	Inferior patella thickness (in mm)
Mean±SD	97.39±3.33	131.35±4.27	13.46±1.03	16.42±1.09
Range	95-105	125-135	12-15	15-18

DISCUSSION

This study was done to test the efficacy of the patellar resection technique which has the potential to enhance flexion in patients undergoing TKA. With this technique it was observed that the preoperative flexion of 95-105º improved to 125-135º post-operatively; with mean increase in the flexion by 33.95±5.30º that is statistically significant ($p<0.05$). Hence, marked improvement in flexion varied between 30-35º with this novel intervention. The joint was observed to be kinematically stable in extension, full flexion and mid-flexion.

Mutsuzaki et al concluded that post-operative flexion post 12 months of TKA was 113.6±15.3º in their study involving the replacement of 39 knee joints.[15] Anouchi et al showed that the post-operative flexion at 24 months was 107±10 º. This study enrolled 621 patients of whom 282 TKAs had a follow-up of 12 months and 86 have a follow-up of 24 months.[16] Dennis et al compared the ranges of motion offered by two TKA designs posterior cruciate-retaining and posterior cruciate substituting TKA in 40 patients. The mean ranges of motion observed were 103 and 113º respectively.[17] The technique used in this study allowed a postoperative flexion of 125-135º. This indicates that this technique enables greater flexion of the knee joint as compared to the previous studies mentioned above.

Numerous techniques have been implemented in the past with the intention of optimizing postoperative flexion. There have been mixed results regarding the efficacy of high flexion implants over standard ones. A meta-analysis by Wang et al published in 2015 confirmed that high flexion implants provided a superior range of motion when compared to standard implants. 16 trials involving 2643 knees were included in this study. However, there was no difference in Knee society scores, Knee society function and Hospital for special surgery scores.[18] Kim et al concluded that there was no significant difference between the ranges of motion, clinical and radiographic parameters observed in standard and high flexion posterior stabilized total knee prostheses. This study was conducted in 50 patients with a mean age of sixty-eight who received a standard fixed-bearing knee prosthesis in one knee and a high flexion fixed-bearing knee prosthesis in the contralateral knee. These patients were followed up for a duration of 24 months.[19] A study conducted in the U.S showed that patients undergoing LPS-Flex TKA and CR-Flex TKA experienced flexion in the range of 105-136º and 90-132º respectively. It was observed that CR-Flex experienced higher medial contact stress than the LPS-Flex throughout flexion. This study published in 2007 recruited 20 patients of which 10 patients underwent fixed bearing high flexion posterior stabilized TKA and the other 10 underwent fixed bearing high flexion posterior cruciate retaining TKA.[8] Ng et al compared the range of motion after standard version posterior stabilized total knee replacement (TKR) and high flexion version TKR in patients receiving bilateral TKR. Range of motion was measured pre-operatively and at the most recent follow-up. 35 patients were recruited in the study. The author concluded that the difference between the two groups was not statistically significant.[20] Tanavalee et al studied 165 patients suffering from advanced osteoarthritis with a minimum 120º pre-operative flexion. These patients were divided into two groups, Group A which were able to perform full range pre-operative flexion (heel to buttock) and Group B which showed an inability to do so. After high flexion TKA with a mean follow-up of 77 months, it was observed that there was no improvement in flexion in Group B. It was also observed that Group A showed reduced flexion (significant change) as compared to their pre-operative measurements.[21] This evidence could be interpreted that the newer high flexion techniques may not be effective in populations with higher pre-operative flexion measurements.

However, the technique studies in this study allowed patients to experience even greater flexion compared to these newer techniques (125-135º). High flexion design requires bone resection from posterior condyles and intercondylar notch. This may weaken the bone supporting load from the femoral component creating a negative impact in the long term when revisions would be performed. The loosening of the femoral component leads to early revisions.[22] A study conducted in the Asian population showed that high flexion design was associated with lower survival and femoral component loosening which required revision of the procedure. Seventy-two patients with Nexgen LPS-flex fixed TKAs were prospectively followed up for 18 months to determine the probability of survival using revision as the endpoint. This study also compared survival between those who could and those who couldn't perform high flexion activities.[9] Since the present technique does not involve the above interventions, it provides greater stability to the joint and reduces morbidity. A prospective and retrospective study was conducted by Jain at Sancheti Institute of Orthopaedics and Rehabilitation in 200 patients. This study included a comparative analysis of two groups of patients undergoing TKR with high flexion knee prosthesis and standard posterior stabilized knee prosthesis respectively. The author concluded that the

PFC sigma implant showed significant improvement in clinical and functional outcome measures with a significant decrease in pain. This implant showed similar functional outcomes as compared to high flexion implants.[23] The novel patellar resection technique used in the present study also utilizes the PFC sigma implant for improved patient outcomes.

Limitations

This study did not utilize control group undergoing conventional TKA or TKA with high flexion designs. This control group would have been used as a baseline for comparison with the patellar resection technique. Although the study assessed the effect of this procedure on the range of motion, it did not take functional outcomes or scores into consideration. Also, long-term follow-up of the patients was not conducted to determine long-term complications of the procedure or the time duration until revision.

CONCLUSION

The novel patellar resection technique can be beneficial for the patients. They can able to follow their native lifestyle and perform their daily activities without any hindrance. The mean increase in the range of flexion was 33.95±5.30º (ranged 30-35º, $p<0.05$). This technique allowed patients to have a greater range of flexion as compared to standard and high flexion designs. Since it does not involve extensive and unnecessary bone resection from the posterior condyles or intercondylar notch, it is hypothesized to be devoid of complications such as femoral component loosening and subsequent revisions. Further studies in a larger population are needed to confirm the efficacy and long-term safety of this procedure.

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Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee

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