



OUTCOME ANALYSIS OF MEDIAL PIVOT KNEE SYSTEM IN TOTAL JOINT ARTHROPLASTY OF KNEE – A NARRATIVE REVIEW

Orthopaedics

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ABSTRACT

Osteoarthritis of knee is a very common and well-known condition since ages. Earlier mankind lived with this debilitating disease with little help to improve the quality of life. With the advent of knee prosthesis in 1969 by Frank Gunston the outlook towards knee pain has changed considerably. Total knee replacement has constantly evolved since then till date to provide the best functioning kinematics to patients. However there has been something lacking in the designs to mimic the natural movement of the knee in flexion and extension. In recent times with various gait and 3-D analysis researchers have found that during knee flexion the lateral condyle moves back and forth about a constant medial axis. Hence they have designed a tibial polyethylene insert with a ball-in socket arrangement for the medial femoral condyle and a less conforming lateral condyle surface. Various studies have been conducted to assess the outcomes of this theoretical possibility in practical circumstance with this design.

KEYWORDS

Knee Arthritis, Medial Pivot, PS knee, CR Knee, Joint Arthroplasty

INTRODUCTION AND BACKGROUND

Knee Osteoarthritis is a clinical condition leading to an altered lifestyle which increases morbidity and mortality in mankind¹. For years the human race has been living with painful knees. It leads to decreased mobility which in turn affects multiple organ system. The end result is an elderly adult who is physically dependent on the society for his daily needs.

To mitigate this disease the medical fraternity invented the concept of replacing the affected parts of the knee with an artificial prosthesis in the shape of the native knee². This opened up the horizons for Total Knee Arthroplasty. Initially invented to relieve pain and improve mobility in elderly persons, TKA has found its way into the lives of young more demanding individuals. The improvement in the quality of life has had an enormous socioeconomic impact⁶.

The goal of knee replacement has been to restore the native knee kinematics and functional dynamics. However the older and new prosthesis designs have been unsuccessful at fulfilling this goal. Till now there has been no Ideal knee prosthesis which can replicate the normal knee mechanics which has resulted in a failure to restore the predicted and physiological knee movements. The overall success and patient satisfaction was in the range of 75%-92%⁷.

Medical human and cadaveric studies have demonstrated that the normal knee kinematics show the lateral condyle pivoting around a fairly stable medial condyle like a ball and socket with the lateral condyle moving front to back, rotating around the center of the medial side. The Medial Pivot Knee system was designed to achieve stability in the antero-posterior direction. This system has an asymmetric Tibial insert with highly congruent medial surface and less geometric lateral surface⁸. The geometry of this design reduces contact stresses and Polyethylene wear⁹. The normal knee pivot motion is recreated by causing the femoral component to rotate around an axis via the medial compartment. The main theoretical advantage was restoration of knee kinematics and stability, optimization of range of motion, improvement of clinical wear rates and preservation of bone stock for revision TKR's.

This review was conducted to evaluate several clinical studies on Medial Pivot Knee systems, its clinical outcome in terms of functional and radiological parameters, patient reported outcome measures and implant survivorship. It aims to help surgeons in their decision making regarding the use of appropriate knee systems for their patients.

Review

MATERIAL AND METHOD

A total of 50 articles were screened for abstract. After reading the full text 12 articles were selected for the literature review. A total of 2017

knee were operated on using either the Medial Pivot knee or posterior stabilized knee system were reviewed. All the knees operated had Kellgren and Lawrence grade 3 or grade 4 OA. They were operated using with MP-TKA, PS-TKA, CR-TKA. Both mechanical and Kinematic TKA studies using MPTKA were included. The operating surgeons across various studies had used either a medial parapatellar or mid-vastus approach. Outcome analysis for majority of studies was done at 3,6,12 months.

Inclusion Criteria

1. Randomised controlled or cohort trials using medial pivot knee systems alone and the ones comparing MPK with other knee systems were included
2. MPK system used in both mechanical and kinematic TKR were included
3. Outcome measures belonging to atleast one of the following knee society score, knee function score, WOMAC score, posterior femoral translation, Kaplan-Meier survivorship, Patient reported outcome measures (PROM's), Oxford Knee Score, EQ-5D index.
4. Only English articles were selected

Exclusion Criteria

1. Duplicated or overlapping data
2. Review articles or scientific conference abstracts
3. Cadaver or model studies
4. Unreported data

RESULTS

A Survey from the arthroplasty registry on 506 knees compared the implant Long-term survivorship between MPK and other cemented knee systems. They found Kaplan-Meier survivorship was at 10 years was 96.3 % (95 % CI, 94.5–98.1). This was higher than that for other knee systems 95.7 % (95 % CI, 95.3–96.2) but this was not statistically significant. Revision rates were 3.1% (16) out of which 9 were aseptic loosening both tibial and femoral component revised, 5 septic loosening and 2 aseptic loosening where only tibial component was revised¹⁰.

In a prospective study on 30 knee operated with medial pivot total knee arthroplasty, the knee society score, function score and posterior femoral translation was evaluated. The study showed significant correlation ($r = 0.56$, $p = 0.0012$) suggesting that all the cases had consistent posterior tibiofemoral AP position (-0.51 ± 0.10) on full flexion lateral radiographs. Hence they ruled out the theory that paradoxical anterior femoral translation occurs during progressive knee flexion. At the final follow-up the knee society and mean function score showed considerable improvement from pre-operative scores (from 61.5 to 90.4 and from 57.8 to 84.7 respectively)¹¹.

A Retrospective comparison study on 374 knees was done between

MPK and PS designs to measure PROM's. The overall patient satisfaction was 89.84%. The MPK group had lesser satisfaction 87.38% compared to PS group which had 90.32%. Pain was the major cause of patient dissatisfaction 80%. However patient dissatisfaction was not significant in MPK vs PS knees ($P=0.663$)¹².

In a retrospective, case control and observational cohort study examined 90 knees matched for age and gender operated with CR knee and MPK knee systems. They observed that post-operative range of motion was significantly better in MPK compared to CR group (119.3 degrees [95%CI, 113.9 to 123.0] versus 112.5 degrees [95%CI, 108.1 to 117.0], $p=0.036$). The post-operative pain was less in the MPK group and this was significant (92.2 points [95%CI, 89.4 to 95.1] versus 85.0 points [95%CI, 82.7 to 87.4], $p=0.001$). Surgical time was shorter for MPK group (104.8 min [95%CI, 97.9 to 111.7] versus 154.9 min [95%CI, 145.2 to 164.6]. Estimated blood loss was significantly lower for the medial pivot design (654 ml [95%CI, 550 to 758] versus 1158 ml [95%CI, 1031 to 1439], $p=0.001$)¹³.

A retrospective study on 120 knees was done to evaluate the knee society score, function score, WOMAC score and Kaplan-Meier survivorship in patient operated for PS- MPK knee designs. There was considerable improvement in the pre-operative and last follow up range of motion, the mean flexion contracture decreased from 7.6° to 1.5° and the mean range of further flexion increased from 115.1° (ROM, 107.5°) to 120.5° (ROM, 119°) ($p<0.05$). The Knee society score and function score, and the WOMAC score for pain and stiffness and function were significantly improved ($p<0.05$). The femoro-tibial angle was improved from a mean of 4.6°±4.5° varus preoperatively to a mean of 5.8°±2.4° valgus postoperatively. The 7-year survival rate according to the Kaplan-Meier method was 98.1%.¹⁴

385 knees were prospectively studied for clinical and radiological outcome after being operated with medial pivot knee system. The Knee score (objective) pre-op = 32.55 ± 12.23, final visit = 92.2 ± 7.99 p -value < 0.0005. The Function score (objective) pre-op = 42.75 ± 12.90, final visit = 82.05 ± 16.26, p -value < 0.0005. The Total score (objective) pre-op = 75.30 ± 18.05, final visit = 174.25 ± 18.03, p -value < 0.0005. The SF-12® (subjective) pre-op = 25.25 ± 6.05, final visit = 47.65 ± 6.94, p -value < 0.0005. The WOMAC Score (subjective) pre-op = 30.75 ± 9.87, final visit = 79.30 ± 17.31, p -value < 0.0005. At final follow-up, on radiological evaluation, the mean femoral valgus angle (a) was 95° (92° to 101°), the mean femoral flexion (γ) was one degree (-2° to four degrees), the mean sigma (σ) angle was 87.5° (range 85°-89°) and the mean beta (β) angle was 88.5° (range 87°-92°). The Kaplan-Meier survivorship analysis showed a cumulative success rate of 98.8% both at five years and at 17 years.¹⁵

An analysis of 55 knees operated with kinematic TKR using MPK knee system were studied via a retrospective approach and the clinical and radiological outcomes were measured. Visual analogue scale showed statistically significant improvement from baseline till 3 months post-op but this remained constant at 1 and 2 years follow-up. Knee society-clinical score showed a mean value of 42 at baseline and an increase up to 94.0 at 24 months. Forgotten joint scores significantly increased between 3, 12, and 24 months after surgery, with a value of 79.17 at 3 months and 89.6 at 2 years of follow-up. A significant difference between the preoperative and postoperative HKA angles was registered, both in valgus and varus knees ($p < 0.001$, $p < 0.001$, respectively). The MPTA was significantly increased after surgery ($p < 0.05$). No significant difference was found between preoperative and postoperative mLDFA, as well as between the mLDFA in the operated limb compared to the contralateral mLDFA (overall $p = 0.589$).¹⁶

A randomized control trial evaluated the early outcomes of MPK vs traditional PS knee system on 40 knees. At 2 years the mean knee flexion was higher in PS than in the MPK group and this difference was statistically significant ($p = 0.013$). The change in mean knee flexion was 9.25° ± 14.26° in the PS group as compared to -6.11° ± 19.74° in the MP group, thus showing worsening of knee flexion in the MP group. There was statistically significant difference only in the objective component of the new Knee Society Score, which was significantly higher in the PS group than in the MP group ($p < 0.001$) due to the increased knee flexion. With respect to the European Quality of life index-5D and Forgotten Joint Score-12 there was no difference. There was no statistical difference in complications between the two groups.¹⁷

A Prospective comparison study conducted on 121 knees to prove that

MPK designs achieved better AP stability and functional performance than the PS designs. The anterior tibial translation was lower in MPK group at both 30 and 60 degree of flexion with statistical difference in at 60 degree flexion for loads of 89N, 111N and 133N. On the VAS pain was same at 3 months for both groups but significantly lower for the MPK group at 6 and 12 months. Post-op knee flexion was similar in both groups. Knee society score and forgotten joint score were significantly different for MPK compared to PS group.¹⁸

A prospective randomized control trial compared the outcome of TKR between MPK and PS systems in 90 knees. There was no statistically significant difference in Range of motion between MP-TKA and PS-TKA respectively at 1 year (114.6° ± 16.3° vs 111.3° ± 17.8° respectively, $P < 0.88$) and 2 year (114.9° ± 15.5° vs 114.9° ± 16.4° respectively, $P < 0.92$). There was no difference between two groups in functional outcomes, WOMAC score 1 year ($P = .12$) 2 year ($P = .14$), Oxford Knee score 1 year ($P = .18$) 2 years ($P = .18$), Knee Society-clinical scores 1 year ($P = .98$) 2 years ($P = .12$), Knee Society-functional Scores 1 year ($P = .27$) 2 years ($P = .62$). There were also no differences between the MPTKA and PS-TKA groups in postoperative limb alignment (1.8° ± 1.2° varus vs 1.2° ± 0.7° varus respectively, $P = .34$).¹⁹

A total of 100 patients were retrospectively reviewed to compare the differences between MP-TKA and PS-TKA. The study showed that there was statistically significant difference between HSS Knee score (hospital for special surgery) and WOMAC knee score pre and post-operatively.²⁰

In a single center prospective RCT, 106 knees were operated to compare the patient satisfaction outcome between MP-TKA and PS-TKA using the Knee Society- satisfaction score, Knee Society-Expectation score and Oxford Knee Scores. At 3 months only KS-satisfaction score was significant. At 6 months . The mean KSS-Satisfaction scores were 32.6±3.41 (24-38) in MP and 29.5±3.26 (22-36) in PS knees ($p<0.0001$) respectively, and the mean KSS-Expectation scores were 11.9 ± 1.37 (8-14) in MP and 11.1±1.24 (8-15) in PS knees ($p<0.0001$) respectively. At 1 year the mean KSS-Satisfaction scores were 34.5±3.05 (26-38) in MP and 31.7±3.16 (24-38) in PS knees ($p<0.0001$) respectively, the mean KSS-Expectation scores were 12.5 ± 1.39 (10-15) in MP and 11.2±1.41 (8-15) in PS knees ($p<0.0001$). The Oxford Knee Score was not statistically significant. There was no significant difference in the range of motion and flexion deformity between the two prosthesis.²¹

DISCUSSION

This Review was conducted to evaluate whether the theoretical superiority of the Medial pivot prosthesis could translate into superior practical outcomes. A systematic review in 2022 on this topic has shown that patients with MPK have similar clinical results and radiographic outcomes as compared to PS designs. Three other articles in recent times have been identified since the publication of the 2022 meta-analysis. Hence we have numerous data to analyze the ROM, PROM, complications and radiographic outcomes.

The Knee Society score both in terms of function and clinical outcomes significantly improved at final follow-up. There was a significant difference in the pre and post-operative parameters. The WOMAC and Forgotten joint scores and Oxford Knee Score showed considerable improvement at Final follow-up, though this was primarily for knee range of motion and overall improvement in pain after MP-TKA. However in one study there was a decreased in knee flexion observed in the MPK group compared to the PS group. In fact one study demonstrated higher patient dissatisfaction in the MPK group in terms of pain. The Quality of life Improvement was similar in both groups. The radiographic parameters revealed no significant change in limb alignment in both groups. The implant survivorship was more in the MPK group but this difference was not significant. The Complication and revision Rates were similar in both groups. The Surgical time and blood loss was reported to be less in the MPK group.

However this review had two limitations, First, in combining randomized control trials and cohort studies simultaneously, the bias caused by different types of trials could not be eliminated. Second, the prostheses brands were not consistent through the trials while the implantation mechanism was similar. More studies need to be done to assess the efficacy of MPK designs particularly on patient satisfaction and implant survivorship.

CONCLUSION

Our review showed that there was improvement in knee Flexion and pain in the Medial Pivot Knees. The choice between MP or PS/CR prosthesis will not affect implant survivorship, Quality of life and overall patient satisfaction, complication rates, implant position and post-operative limb alignment.

Additional Information:

Disclosures:

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