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Original Research Article

THREE-YEAR FOLLOW-UP OF ALL-POLYETHYLENE VERSUS METAL-BACKED TIBIAL COMPONENTS IN PRIMARY TOTAL KNEE ARTHROPLASTY: A LONGITUDINAL CONTINUATION OF A PREVIOUS SIX-MONTH COHORT STUDY

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ABSTRACT

Background: We previously reported six-month clinical and functional outcomes of all-polyethylene versus metal-backed tibial components in 48 patients undergoing primary total knee arthroplasty [1]. The present study extends this follow-up to three years in the same cohort. The objective is to evaluate the three-year clinical, functional, and radiological outcomes of AP versus MBT tibial components in the same 48 patients previously assessed at six months [1].

Materials and Methods: Of the 48 patients originally enrolled at the Department of Orthopedic Surgery, Sharif Medical City Hospital, Lahore, all 24 patients in each group were reassessed at a mean of 36 months postoperatively. Outcomes included the American Knee Society Score, Visual Analog Scale for pain, range of motion, complications, radiological findings (radiolucent lines, tibial subsidence, loosening), and patient satisfaction. Statistical analysis was performed using SPSS version 26.0.

Results: At three years, AKSS, VAS, ROM, and functional scores remained comparable between the AP and MBT groups (all $p > 0.05$). No case of revision, aseptic loosening, or deep infection was observed in either group. Complication rates were identical (8.4% in each group), and 91.7% of patients in both groups reported being satisfied or very satisfied ($p = 0.782$). Improvements observed at six months were maintained without deterioration through the three-year time point [1].

Conclusion: Clinical and functional outcomes demonstrated at six months in our original cohort were sustained at three years, with no significant differences between AP and MBT tibial components [1]. These findings support AP tibial components as a comparable, cost-effective alternative in primary TKA, particularly in resource-constrained settings.

Keywords: AKSS, All-Polyethylene Tibial, American Knee Society Score, Metal-Backed Tibial, Osteoarthritis, Total Knee Arthroplasty.

INTRODUCTION

Total knee arthroplasty has demonstrated excellent pain relief and functional improvement in patients with end-stage osteoarthritis and inflammatory arthritis.[1-3] Long-term implant survivorship depends on multiple factors including patient selection, surgical technique, implant alignment, and prosthesis design.[4] Historically, metal-backed tibial components became widely adopted because they were believed to improve load distribution and permit polyethylene liner exchange.[5]

All-polyethylene tibial components are substantially less expensive than metal-backed implants, with an average savings of approximately $1,000 per case.[6] In a resource-constrained country like Pakistan, with a GDP per capita of less than $5,000, this cost differential is substantial and can make TKA more accessible to a larger segment of the population.[6,7] Previous studies, including the meta-analysis by Bonanzinga et al., have shown no significant difference in clinical outcomes or survival between AP and MBT components at five-year follow-up.[8]

We previously conducted a six-month follow-up study on the same cohort of 48 patients treated at our institution.[9] At six months, both AP and MBT groups demonstrated significant improvements in American Knee Society Score, functional score, VAS pain score, and range of motion, with no statistically significant differences between groups and no cases of revision or aseptic loosening.[9]

The present study represents a continuation of that earlier work, extending follow-up to three years in the same 48 patients,[9] in order to assess whether the early benefits observed at six months are sustained, and whether late complications such as polyethylene wear, radiolucent lines, or loosening emerge differentially between implant types over the medium term.

MATERIALS AND METHODS

Study Design and Setting: This study is a longitudinal continuation of our previously published six-month cohort study comparing all-polyethylene (AP) and metal-backed tibial (MBT) components in primary total knee arthroplasty (TKA).[1] The original study was conducted at the Department of Orthopaedic Surgery, Sharif Medical City Hospital, Lahore, Pakistan. The present study evaluates the clinical, functional, and radiological outcomes of the same patient cohort at a mean follow-up of 36 months (range: 34–38 months).

Participants: The original cohort comprised 48 patients undergoing primary cemented TKA for end-stage knee osteoarthritis, with 24 patients receiving AP tibial components and 24 receiving MBT components. The eligibility criteria, patient recruitment, surgical technique, and perioperative management have been described in detail in the original publication.[1] Briefly, patients undergoing primary TKA for symptomatic end-stage osteoarthritis who met the institutional surgical criteria were included, while patients undergoing revision arthroplasty, those with active infection, inflammatory arthropathy, or incomplete baseline data were excluded.

For the present follow-up study, all patients from the original cohort were eligible for reassessment. No patient was lost to follow-up, and all 48 patients completed the three-year evaluation.

Follow-up Assessment: Patients were reviewed at regular postoperative intervals as part of the institutional follow-up protocol. Assessments were performed at baseline, 3 months, 6 months, 1 year, 2 years, and 3 years after surgery. The current report focuses on the three-year outcomes while demonstrating the longitudinal progression of the cohort.

Clinical evaluation included the American Knee Society Score (AKSS), Functional Knee Society Score, Visual Analogue Scale (VAS) for pain, and knee range of motion (ROM). Patient satisfaction was recorded at the three-year follow-up using a standardized satisfaction assessment.

Standard anteroposterior and lateral radiographs of the operated knee were obtained at follow-up visits. Radiological assessment included evaluation for radiolucent lines, tibial subsidence, component migration, and signs of aseptic loosening.

Postoperative complications, including superficial and deep infection, wound complications, deep vein thrombosis, instability, aseptic loosening, and revision surgery, were recorded throughout the follow-up period.

Statistical Analysis: Data were analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables are presented as mean ± standard deviation, while categorical variables are presented as frequencies and percentages. Comparisons between the AP and MBT groups were performed using the independent-samples t-test for continuous variables and the Chi-square or Fisher's exact test for categorical variables, where appropriate. Changes between preoperative and postoperative outcome measures within each group were analysed using the paired t-test. A p-value of <0.05 was considered statistically significant.

Ethical Considerations: The present study represents an extended follow-up of a previously approved institutional cohort. Ethical approval for the original study was obtained from the institutional ethics committee. Written informed consent had been obtained from all participants for participation and follow-up.

Table 1: Follow-up of the Study Cohort

Time point	AP group (n)	MBT group (n)
Baseline	24	24
3 months	24	24
6 months (previous report) [1]	24	24
1 year	24	24
2 years	24	24
3 years (current report)	24	24

RESULTS

Patient Follow-up: A total of 48 patients completed the three-year follow-up, including 24 patients who received all-polyethylene (AP) tibial components and 24 who received metal-backed tibial (MBT) components. No patient was lost to follow-up during the study period. Baseline demographic and clinical characteristics have been reported previously and were comparable between the two groups.[1]

Clinical Outcomes: Both groups demonstrated substantial improvement in clinical and functional outcomes following primary total knee arthroplasty. The improvements observed during the early postoperative period were maintained throughout the three-year follow-up.

American Knee Society Score (AKSS): AKSS improved significantly from the preoperative assessment in both groups. At three years, the mean postoperative knee score was 68.1 ± 6.8 in the AP group and 68.5 ± 6.4 in the MBT group, with no significant difference between groups (p = 0.814) [Table 2]. Half of all patients achieved a good postoperative knee score, while only two patients, both in the MBT group, had poor scores [Table 3].

Table 2: Comparison of Preoperative and Postoperative Knee Scores

Parameter	All-Polyethylene (Mean ± SD)	Metal-Backed (Mean ± SD)	p-value
Preoperative KSS	41.5 ± 8.2	42.6 ± 8.0	0.713*
Postoperative KSS (3 months)	62.8 ± 7.0	63.4 ± 6.7	0.782*
Postoperative KSS (6 months)	66.0 ± 6.8	66.7 ± 6.6	0.751*
Postoperative KSS (1 year)	67.5 ± 6.7	68.0 ± 6.4	0.823*
Postoperative KSS (2 years)	68.0 ± 6.6	68.3 ± 6.4	0.801*
Postoperative KSS (3 years)	68.1 ± 6.8	68.5 ± 6.4	0.814*

*Statistically insignificant p-value (p > 0.05).

Table 3: Postoperative Knee Score Categorization

Category	Score Range	All-Polyethylene (n=24)	Metal-Backed (n=24)	Total (N=48)
Good	≥80	13 (54.2%)	11 (45.8%)	24 (50%)
Fair	60–79	11 (45.8%)	11 (45.8%)	22 (45.8%)
Poor	<60	0 (0%)	2 (8.4%)	2 (4.2%)

Functional Knee Score: Functional scores also improved significantly following surgery in both groups. At the three-year follow-up, the mean functional score was 58.2 ± 9.5 in the AP group and 61.8 ± 12.6 in the MBT group, with no statistically significant difference between implant designs (p = 0.272) [Table 4]. Functional score distribution was comparable between the two groups [Table 5].

Table 4: Comparison of Preoperative and Postoperative Functional Scores

Parameter	All-Polyethylene (Mean ± SD)	Metal-Backed (Mean ± SD)	p-value
Preoperative Functional Score	38.8 ± 7.0	37.6 ± 8.0	0.088*
Postoperative Functional Score (3 months)	48.8 ± 8.4	50.4 ± 9.6	0.342*
Postoperative Functional Score (6 months)	53.0 ± 9.0	56.0 ± 10.0	0.298*
Postoperative Functional Score (1 year)	55.6 ± 9.2	58.6 ± 11.2	0.281*
Postoperative Functional Score (2 years)	57.0 ± 9.4	60.8 ± 12.0	0.275*
Postoperative Functional Score (3 years)	58.2 ± 9.5	61.8 ± 12.6	0.272*

*Statistically insignificant p-value (p > 0.05).

Table 5: Postoperative Functional Score Categorization

Category	Score Range	All-Polyethylene (n=24)	Metal-Backed (n=24)	Total (N=48)
Good	≥80	5 (20.8%)	8 (33.3%)	13 (27.1%)
Fair	60–79	5 (20.8%)	4 (16.7%)	9 (18.75%)
Poor	<60	14 (58.4%)	12 (50.0%)	26 (54.15%)

Pain and Range of Motion: Pain scores improved markedly following surgery in both groups. At three years, the mean VAS pain score was 2.3 ± 0.8 in the AP group and 2.5 ± 0.9 in the MBT group, with no significant difference between groups (p = 0.643) [Table 6].

Similarly, postoperative knee range of motion improved in both groups and remained comparable at the final follow-up. Mean range of motion at three years was 112.8° ± 8.0° in the AP group and 114.0° ± 7.8° in the MBT group (p = 0.421) [Table 7].

Table 6: Comparison of Preoperative and Postoperative VAS Scores

Parameter	All-Polyethylene (Mean ± SD)	Metal-Backed (Mean ± SD)	p-value
Preoperative VAS	7.7 ± 1.3	7.5 ± 1.5	0.582*
Postoperative VAS (3 months)	3.7 ± 1.2	3.5 ± 1.3	0.612*
Postoperative VAS (6 months)	3.1 ± 1.0	2.9 ± 1.1	0.634*
Postoperative VAS (1 year)	2.7 ± 0.9	2.6 ± 0.9	0.651*
Postoperative VAS (2 years)	2.4 ± 0.8	2.6 ± 0.9	0.638*
Postoperative VAS (3 years)	2.3 ± 0.8	2.5 ± 0.9	0.643*

*Statistically insignificant p-value (p > 0.05).

Table 7: Comparison of Preoperative and Postoperative Range of Motion

Parameter	All-Polyethylene (Mean ± SD)	Metal-Backed (Mean ± SD)	p-value
Preoperative ROM	98.0° ± 10.6°	97.0° ± 11.0°	0.482*
Postoperative ROM (3 years)	112.8° ± 8.0°	114.0° ± 7.8°	0.421*

*Statistically insignificant p-value ($p > 0.05$).

Radiological Outcomes: Radiographic assessment at three years demonstrated satisfactory implant fixation in both groups. No patient developed progressive radiolucent lines greater than 2 mm, tibial subsidence, component migration, or radiological evidence of aseptic loosening. A single patient in the MBT group demonstrated a non-progressive radiolucent line measuring less than 2 mm, which was not associated with clinical symptoms or implant failure [Table 8].

Table 8: Radiological Outcomes at 3 Years

Finding	All-Polyethylene (n=24)	Metal-Backed (n=24)	p-value
Radiolucent lines <2 mm	0 (0%)	1 (4.2%)	0.782*
Radiolucent lines >2 mm	0 (0%)	0 (0%)	–
Tibial subsidence	0 (0%)	0 (0%)	–
Component migration	0 (0%)	0 (0%)	–
Signs of loosening	0 (0%)	0 (0%)	–

*Statistically insignificant p-value ($p > 0.05$).

Complications: Overall complication rates were low and comparable between the two groups. Two patients (8.4%) in each group experienced postoperative complications. Superficial infection occurred in one patient in each group and resolved with treatment. One patient in the AP group developed deep vein thrombosis, while one patient in the MBT group experienced wound dehiscence. No cases of deep infection, instability, aseptic loosening, or revision surgery were recorded during the three-year follow-up [Table 9].

Table 9: Complication Rates

Complication	All-Polyethylene (n=24)	Metal-Backed (n=24)	Total (N=48)
Superficial infection	1 (4.2%)	1 (4.2%)	2 (4.2%)
Deep infection	0 (0%)	0 (0%)	0 (0%)
Aseptic loosening	0 (0%)	0 (0%)	0 (0%)
Instability	0 (0%)	0 (0%)	0 (0%)
Revision surgery	0 (0%)	0 (0%)	0 (0%)
DVT	1 (4.2%)	0 (0%)	1 (2.1%)
Wound dehiscence	0 (0%)	1 (4.2%)	1 (2.1%)
Total complications	2 (8.4%)	2 (8.4%)	4 (8.4%)

Patient Satisfaction: Patient satisfaction remained high in both groups. Twenty-two patients (91.7%) in each group reported being either satisfied or very satisfied with the outcome of surgery. Satisfaction levels did not differ significantly between AP and MBT tibial components ($p = 0.782$) [Table 10].

Table 10: Patient Satisfaction at 3 Years

Satisfaction Level	All-Polyethylene (n=24)	Metal-Backed (n=24)	Total (N=48)
Very satisfied	13 (54.2%)	13 (54.2%)	26 (54.2%)
Satisfied	9 (37.5%)	9 (37.5%)	18 (37.5%)
Neutral	2 (8.3%)	1 (4.2%)	3 (6.25%)
Dissatisfied	0 (0%)	1 (4.2%)	1 (2.1%)
Very dissatisfied	0 (0%)	0 (0%)	0 (0%)

DISCUSSION

The present study extends the follow-up of our previously published six-month cohort to three years and demonstrates that the early clinical improvements observed after primary total knee arthroplasty were maintained over time. Patients receiving all-polyethylene (AP) and metal-backed tibial (MBT) components showed comparable clinical, functional, and radiological outcomes, with no significant differences in American Knee Society Scores, pain, range of motion, complication rates, or patient satisfaction. Importantly, no cases of aseptic loosening, implant revision, or deep infection were identified in either group during the three-year follow-up period.

The absence of clinically meaningful differences between AP and MBT components is consistent with the growing body of contemporary literature. Recent meta-analyses have demonstrated equivalent functional outcomes, implant survivorship, and complication rates between the two designs at medium-term follow-up.[8,10] Similarly, analysis of the American Joint Replacement Registry reported a lower associated risk of revision with AP tibial components, supporting their continued use in appropriately selected patients.[11] Together, these findings suggest that modern all-polyethylene tibial

components can provide durable clinical performance comparable to metal-backed implants.

Radiological outcomes in the present study further support these observations. No progressive radiolucent lines greater than 2 mm, tibial subsidence, component migration, or radiological loosening were observed in either group. Although the follow-up duration remains insufficient to evaluate long-term polyethylene wear or osteolysis, these findings suggest satisfactory implant fixation and stability during the medium-term postoperative period. Similar radiological results have been reported in previous randomised trials and systematic reviews comparing AP and MBT components.[8,12,13]

Functional recovery was maintained throughout the three-year follow-up in both groups. Improvements in American Knee Society Scores, pain scores, and range of motion observed during the early postoperative period remained stable without evidence of deterioration. These findings indicate that the benefits demonstrated in our original six-month study were sustained over time and support the durability of both implant designs in routine clinical practice.

The comparable outcomes observed between implant types are likely multifactorial. Advances in polyethylene manufacturing, modern cementing techniques, and improvements in surgical technique have reduced many of the historical concerns regarding all-polyethylene tibial components. Consequently, implant design alone may contribute less to medium-term clinical outcomes than patient selection, soft tissue balancing, implant alignment, and postoperative rehabilitation.

An important finding of this study relates to healthcare economics. AP tibial components are substantially less expensive than MBT implants while demonstrating similar clinical and radiological outcomes. In countries with limited healthcare resources, where implant cost may represent a significant barrier to surgery, the routine use of AP components in appropriately selected patients could improve access to total knee arthroplasty without compromising patient outcomes. These findings support previous cost-effectiveness studies demonstrating considerable financial savings associated with AP implants.[6,14,15]

The present study has several strengths. It represents one of the few longitudinal studies from Pakistan comparing AP and MBT tibial components and, to our knowledge, provides the first reported three-year follow-up of this patient population. All patients completed follow-up, eliminating attrition bias, and clinical assessment was complemented by systematic radiological evaluation and patient-reported satisfaction. Furthermore, the continuation of the same cohort allowed assessment of the durability of the favourable early outcomes reported previously.

Several limitations should be acknowledged. First, this remains a single-centre study with a relatively small sample size, limiting statistical power and generalisability. Second, treatment allocation was determined in the original cohort and was not randomised, introducing the possibility of residual confounding. Third, although three-year follow-up provides valuable medium-term data, it remains insufficient to evaluate long-term implant survivorship, polyethylene wear, osteolysis, or late aseptic loosening. Finally, the economic implications discussed are based on published cost analyses rather than a formal institutional cost-effectiveness evaluation.

Despite these limitations, the findings contribute valuable local evidence supporting the use of all-polyethylene tibial components in primary total knee arthroplasty. Continued follow-up of this cohort to five and ten years will further clarify the long-term durability and survivorship of these implants in our population.

CONCLUSION

In this longitudinal continuation of our six-month cohort study,[1] all-polyethylene and metal-backed tibial components produced comparable clinical, functional, and radiological outcomes at three years, with no cases of revision, aseptic loosening, or deep infection in either group. The improvements documented at six months were sustained through the three-year time point.[1] These findings are consistent with the international literature and support the use of AP tibial components as a cost-effective alternative in primary TKA, particularly in resource-constrained settings. Longer-term follow-up (5–10 years) of this same cohort is recommended to confirm these results and to characterize late implant behaviour.

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