

# Comparison of All-Polyethylene Tibial Versus Metal-Backed Tibial Component in Total Knee Replacement Surgery

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## ABSTRACT

**Introduction:** Total knee replacement (TKR) is the most successful procedure in Orthopedics. The selection of an ideal implant relies on better survivorship, restoration of functional activities and cost-effectiveness. This study compared the effectiveness of all-polyethylene (AP) versus metal-backed tibial (MTB) implant in TKR patients in terms of objective and subjective patient related outcomes.

**Objectives:** To compare the effectiveness of all-polyethylene tibial implants versus metal-backed tibial implants in total knee replacement patients in terms of improvement in the American Knee Society Score (AKSS).

**Methodology:** It was a nonrandomized controlled trial done in the Orthopaedic Department of the Sharif Medical City Hospital, Lahore, after approval by the institutional ethical committee. Fifty patients of grade IV knee joint osteoarthritis for greater than six months were included by nonprobability convenient sampling technique. The patients were allocated equally into standard treatment and intervention groups; patients underwent TKR with MTB implants in the standard group and AP implants in the intervention group after taking informed written consent. The AKSS score was calculated pre-operatively, 3 months and 6 months after surgery by the team member not involved in surgical planning.

**Results:** A statistically significant improvement was observed in pre-operative to post-operative knee scores (p-value = 0.004) and functional scores (p-value = 0.001) with TKR. When the means of knee scores were compared between AP and MTB implants, there was no significant difference between the two groups between pre-operative and post-operative knee scores and functional scores.

Practical implication

**Conclusion:** There is no significant difference in knee score between the all-polyethylene and metal-backed implants regarding pain and functional status. All-polyethylene implants are a better substitute for MTB implants due to their cost-effectiveness, particularly in countries with financial constraints. The most practical implication of the current study is health economics. In a developing country with a low per capita income, expensive implants can be swapped with low cost implants to bring the cost of the procedure down.

**Keywords:** All-polyethylene tibial, Metal-backed tibial, Total knee replacement, American Knee Society Score, AKSS.

## INTRODUCTION

Knee osteoarthritis is a usual common presentation in outdoor patient department. It contributes to a major proportion of healthcare burden, disability and financial costs affecting 250 million people globally.<sup>1,2</sup> It damages the articular cartilage of the joint. This condition can be primary or secondary. Primary osteoarthritis is without any known etiology, although family history and age-related changes predispose to this condition. Secondary osteoarthritis is due to secondary pathologies like trauma, inflammatory arthritis, mainly rheumatoid arthritis, avascular necrosis and crystal deposition diseases.<sup>3</sup>

The patient presents with pain initially, which worsens with activity, diffuse swelling, and inability to perform daily life activities. In the later stages, deformity of the knee joint occurs, which results in the change of the mechanical axis around the knee.<sup>4</sup> Kellgren and Lawrence have graded this condition according to the severity of symptoms. There are four grades of osteoarthritis, ranging from mild symptoms to advanced articular damage and deformity.<sup>5</sup>

The initial management is directed to relieve the symptoms and activity modification. For the advanced stages and in case of failure of conservative management, total knee replacement (TKR) is the definitive treatment. This surgery is the most successful procedure in Orthopedics, and the damaged articular surface is changed with the implants.<sup>6</sup> The majority of the patients have an excellent clinical outcome after surgery. With a rise in average age and arthritis in the geriatric population, the need for TKR is increasing.<sup>7</sup>

Total knee replacement has become the most common surgical procedure in Orthopedics nowadays. The selection of an ideal implant relies on better survivorship, restoration of functional activities and cost-effectiveness.<sup>8</sup> All-polyethylene (AP) tibial implant was initially used for TKR with satisfactory results. However, failure rates of 17% were reported with these implants with deformity of the implant. After that, metal-backed tibial (MBT) implants were introduced associated with greater intra-operative flexibility, decreased deformity and better load distribution to the

underlying bone. However, these implants also have limitations of higher cost, need for increased resection of bone and greater tensile stress.<sup>9</sup>

The cost of a TKR implant ranges from 150,000 to 550,000 PKR, depending on the make and model of the implant. In a resource-constrained country like ours, with a GDP of less than 5 USD, this surgery is expensive and has a significant financial burden on the patients. The price of an MTB implant is \$2,054. On the other hand, the price of an AP implant is \$1,009. The cost of TKR can be brought down by using AP implants. There is an average savings of \$1,000 when an AP implant is used instead of an MTB implant.<sup>10</sup>

This study was conducted to compare the effectiveness of all polyethylene tibial versus metal-backed tibial implants in TKR patients in terms of objective and subjective patient-related outcomes. Although there is a significant amount of literature on this topic internationally, there is no local study on this subject. All-polyethylene implants are cost-effective as compared to metal-backed implants. This study can have a significant impact on TKR patients, especially in terms of the cost-effectiveness, and more work can be directed in the future for multicenter trials.

**Objectives:** To compare the effectiveness of all-polyethylene tibial implants versus metal-backed tibial implants in total knee replacement patients in term of improvement in the American Knee Society Score (AKSS).

## METHODOLOGY

It was a nonrandomized controlled trial done in the Orthopaedic Department of the Sharif Medical City Hospital, Lahore, after approval by the institutional ethical committee. Fifty patients of grade IV knee joint osteoarthritis for greater than six months were included in the study by nonprobability convenient sampling. The patients with a history of recent knee trauma, knee instability, recent steroid injection within 3 months, severe anemia, thrombocytopenia, bleeding disorder, uncontrolled diabetes mellitus and hypertension were excluded. The patients were

allocated into two groups: 25 patients in the standard treatment group and 25 patients in the intervention group. After taking informed written consent, the standard treatment group underwent TKR using a metal-backed tibial component under spinal anesthesia, whereas, the intervention group underwent TKR using an all-polyethylene tibial component under spinal anesthesia. A medial parapatellar arthrotomy was done using a midline incision. The AKSS score was calculated pre-operatively, 3 months and 6 months after surgery by the team member not involved in surgical planning.

Cemented Total knee replacement was carried out in modular type A theatre by a single surgeon. Second-generation cephalosporin was given prophylactically. Implants from standard implant company having drug regulatory authority Pakistan (DRAP) registration number, company lot number and specifications were utilized. Pulse lavage and pressurization cementing techniques were used for both groups. Prophylactic thromboprophylaxis using oral factor Xa inhibitor was given post-operatively for up to 2 weeks. Standard rehabilitation protocol using continuous passive motion machine (CPM) from post-operative day 1 and full weight bearing was carried out. Patients were discharged on post-operative day 2 with all the necessary wound and rehabilitation instructions.

The AKSS score evaluates pain, stability and joint movement range. It has two components: knee score and functional score. Possible scores range from 0 to 100, in which a score of 100 shows no pain with good joint alignment and range of movement. The interpretation of the AKSS score is shown in Table 1.

Table 1: American Knee Society Score (AKSS) Interpretation

| American Knee Society Score (AKSS) | Interpretation |
|------------------------------------|----------------|
| 85-100                             | Excellent      |
| 70-84                              | Good           |
| 60-69                              | Fair           |
| <60                                | Poor           |

**Statistical Analysis:** The data was analyzed using the Statistical Package for the Social Sciences (SPSS) version 25. The quantitative variables such as age, body weight, body mass index (BMI) and AKSS score were calculated using mean and standard deviation (SD). The qualitative variables such as gender, age groups, laterality, co-morbidities and scoring of AKSS score were represented by frequency and percentage. An independent t-test was applied to compare the pre-operative and 6-month post-operative knee scores and functional scores between the AP and MTB implant groups. Chi-square test was also applied to compare the categories of pre-operative and post-operative knee scores and functional scores and compare the scores between two groups. The significant p-value was ≤ 0.05.

Table 3: Pre-operative and Post-operative Knee Scores and Functional Scores

| Category  | Pre-op Knee Score | Post-op Knee Score | p-value | Pre-op Functional Score | Post-op Functional Score | p-value |
|-----------|-------------------|--------------------|---------|-------------------------|--------------------------|---------|
| Excellent | 0                 | 0                  | 0.004*  | 0                       | 0                        | 0.001*  |
| Good      | 0                 | 25                 |         | 0                       | 13                       |         |
| Fair      | 9                 | 23                 |         | 11                      | 9                        |         |
| Poor      | 41                | 2                  |         | 39                      | 28                       |         |

\*Statistically significant p-value

Table 4: Comparison of Means of Pre-op and Post-op Knee Scores and Functional Scores between AP and MTB Groups

| AKSS                          | All-polyethylene | Metal-backed | p-value |
|-------------------------------|------------------|--------------|---------|
| Pre-op Knee Society Score     | 52.04±6.90       | 52.80±7.57   | 0.713** |
| Pre-op Knee Functional Score  | 44.20±10.57      | 48.60±14.03  | 0.217** |
| Post-op Knee Society Score    | 67.96±6.69       | 68.4±6.45    | 0.814** |
| Post-op Knee Functional Score | 57.24±9.48       | 61.96±12.81  | 0.145** |

\*\* Statistically insignificant p-value

When the means of knee scores were compared between the AP and MTB implants, there was no significant difference

## RESULTS

The patients had a mean age of 54.8±8.06 years ranging from 41-68 years. The age group 41-50 years had the greatest number of participants (42%), followed by 61-70 years (30%). Most of the patients were females (68%). The mean body weight of the patients was 80.2±7.4 kg. with a minimum weight of 55 kg and a maximum weight of 95 kg. The patients' mean body mass index (BMI) of the patients was 29.1±2.98 kg/m<sup>2</sup>. Patients had a minimum BMI of 19.20 kg/m<sup>2</sup> and the maximum BMI of 36.50 kg/m<sup>2</sup>. The mean pre-operative knee score was 52.4±7.18 ranging from 36-67. The mean pre-operative functional score was 46.4±12.49, with the range of 20-65. The post-operative knee score was 68.1±6.51 ranging from 50 to 80. The mean post-operative functional score was 59.6±11.40. The minimum and maximum post-operative functional scores were 35 and 76, respectively (Table 2)

Table 2: Demographic Variables of the Patients

| Characteristics             | Frequency (Percent) |
|-----------------------------|---------------------|
| Age Groups                  |                     |
| 41-50 years                 | 21(42%)             |
| 51-60 years                 | 14(28%)             |
| 61-70 years                 | 15(30%)             |
| Gender                      |                     |
| Males                       | 16(32%)             |
| Females                     | 34(68%)             |
| BMI Groups                  |                     |
| 18.5-24.9 kg/m <sup>2</sup> | 3(6%)               |
| 25-29.9 kg/m <sup>2</sup>   | 29(58%)             |
| >30 kg/m <sup>2</sup>       | 18(36%)             |
| Laterality                  |                     |
| Unilateral                  | 10(20%)             |
| Bilateral                   | 40(80%)             |
| Diagnosis                   |                     |
| Primary osteoarthritis      | 46(92%)             |
| Secondary osteoarthritis    | 4(8%)               |
| Co-morbidity                |                     |
| HTN                         | 21(42%)             |
| DM                          | 4(8%)               |
| HTN + DM                    | 4(8%)               |
| No co-morbidity             | 21(42%)             |
| Characteristics             | Mean ± SD           |
| Age (Years)                 | 54.8±8.06           |
| Body weight (kg)            | 80.2±7.4            |
| BMI (kg/m <sup>2</sup> )    | 29.1±2.98           |

A statistically significant improvement was observed in pre-operative to post-operative knee scores (p-value = 0.004) and functional scores (p-value = 0.001). These results are shown in Table 3.

between the two groups between pre-operative and post-operative knee scores and functional scores (Table 4).

When the scoring of knee scores was compared between the AP and MTB groups, there was no significant difference between the two groups. The pre-operative and post-operative knee scores were statistically insignificant between all-polyethylene and metal-backed groups with p-value of 0.713 and 0.959, respectively. Similarly, the p-value of pre-operative and post-operative functional scores was statistically insignificant between all-polyethylene and metal-backed groups (p-value = 0.088, p-value = 0.272, respectively) (Table 5).

Table 5: Comparison of Scoring of Pre-op and Post-op Knee Scores and Functional Scores between AP and MTB Groups

| Knee Score                      | Type of Implant  |              | Total | p-value |
|---------------------------------|------------------|--------------|-------|---------|
|                                 | All-polyethylene | Metal-Backed |       |         |
| <b>Pre-op Knee Score</b>        |                  |              |       |         |
| Good                            | 0                | 0            | 0     | 0.713** |
| Fair                            | 4                | 5            | 9     |         |
| Poor                            | 21               | 20           | 41    |         |
| Total                           | 25               | 25           | 50    |         |
| <b>Post-op Knee Score</b>       |                  |              |       |         |
| Good                            | 12               | 13           | 25    | 0.959** |
| Fair                            | 12               | 11           | 23    |         |
| Poor                            | 1                | 1            | 2     |         |
| Total                           | 25               | 25           | 50    |         |
| <b>Pre-op Functional Score</b>  |                  |              |       |         |
| Good                            | 0                | 0            | 0     | 0.088*  |
| Fair                            | 3                | 8            | 11    |         |
| Poor                            | 22               | 17           | 39    |         |
| Total                           | 25               | 25           | 50    |         |
| <b>Post-op Functional Score</b> |                  |              |       |         |
| Good                            | 4                | 9            | 13    | 0.272** |
| Fair                            | 5                | 4            | 9     |         |
| Poor                            | 16               | 12           | 28    |         |
| Total                           | 25               | 25           | 50    |         |

\*\* Statistically insignificant p-value

## DISCUSSION

After the introduction of MBT implants, they have become the implants of choice in total knee replacement due to added benefits of improved biomechanics and flexibility. But they are associated with disadvantages of increased cost and complications such as osteolysis, and backside wear. Literature has reported no significant difference in patients' outcomes with all-polyethylene and metal-backed implants. In addition, all-polyethylene implants are cheaper, reducing the economic constraints on the healthcare systems.<sup>11</sup>

In our study, participants had a mean age of 54.8±8.06 years ranging from 41-68 years. The age group 41-50 years had the greatest number of participants (42%), followed by 61-70 years (30%). In another study, patients had a mean age of 60.4±6.12 years ranging from 50-80 years. Most of the patients were 61-70 years old (53%), followed by 51-60 years (32%).<sup>12</sup> Kriplani et al. reported that a major proportion of patients were >60 years old. In our study, 68% of the patients were females. In another study, there were 50.8% females and 49.2% males.<sup>13</sup> Our results showed that most of the patients had primary osteoarthritis (92%), and only 8% patients had secondary osteoarthritis. Similarly, Siddiqi et al. reported that 91.1% of the patients had primary osteoarthritis.<sup>12</sup> In our study, 80% of the patients had bilateral knee osteoarthritis, while in another study, 91.1% of the patients had bilateral arthritis.<sup>12</sup> In contrast, in a study, the unilateral knee was involved in 68.9% and bilateral knee in only 31.1% of the patients.<sup>13</sup> In our study, 42% of the patients were hypertensive, 8% were diabetic, and 21% had no co-morbidity. In a study by Kriplani et al., 32.7% of the patients were hypertensive, 16.7% were diabetic, and 36.1% of the patients had no co-morbidity.<sup>13</sup>

Our results showed that the post-operative knee score in patients with the all-polyethylene implants was good in 48%, fair in 48% and poor in 4% of the patients. The post-operative functional score in the all-polyethylene group was good in 16%, fair in 20% and poor in 64% of the patients. In another study, in patients undergoing TKR with an all-polyethylene implant, 8.8% of the patients had excellent, 44.1% had good, 35.2% had fair, and 11.7% had poor knee scores. The functional knee score was good in 32.3%, fair in 41.1% and poor in 26.4% of the patients.<sup>12</sup>

Our results showed the mean post-operative knee score was 67.96±6.69 in the all-polyethylene group and 68.4±6.45 in the MTB group with an insignificant p-value of 0.814. Similarly, the mean post-operative functional knee score was 57.24±9.48 and 61.96±12.81 in the AP and MTB group, respectively. Similar results were reported in other studies. A systematic review

reported that the mean AKSS score was 82.4 with MBT and 81.3 with AP implants. Similarly, the mean functional AKSS score was 73.9 and 74.9 with MBT and AP implants, respectively. The difference in scores was statistically insignificant.<sup>14</sup> Hasan et al. revealed in their study that KSS knee score and KSS functional score did not differ significantly between the AP and MTB implant groups.<sup>15</sup> Another study was done in which patients undergoing TKR with AP implants were compared with MTB implants. The mean AKSS score was 83.4±19.2 with AP implants and 84.9±18.2 with MTB implants (p-value=0.631). The mean functional AKSS score was 75.4 ±15.3 in the AK group and 73.2±16.2 in the MTB group (p-value=0.472). The range of movement was also the same in the two groups. There was also no significant variation in graft survival at five years. In addition, AP implants were cost-effective, leading to a saving of £406.<sup>16</sup> Lewallen et al. reported that AP implants are better than MTB implants in terms of better survivorship and lower reversion rates.<sup>17</sup>

In contrast, Kriplani et al. reported a significant improvement in post-operative functional knee scores in the MTB group. However, no significant difference was seen in the post-operative knee scores between the two groups.<sup>13</sup> Kumar et al. recommended that an all-polyethylene implant is an inexpensive alternative to MTB implants with comparable knee scores and lower revision risk.<sup>18</sup>

## CONCLUSION

There is no significant difference in knee score between the all-polyethylene and metal-backed implants regarding pain and functional status. All-polyethylene implants are a better substitute for MTB implants due to their cost-effectiveness, particularly in countries with financial constraints.

**Recommendations of the Study:** Further randomized controlled trials should be carried out with a larger sample size. The reversion rate of implants should also be assessed with a longer follow-up.

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