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Original Article

Innovations in Knee Arthroplasty: Comparative Effectiveness of Cemented vs. Cementless Prostheses

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ABSTRACT

Background: Advances in implant design have renewed interest in cementless total knee arthroplasty (TKA) as an alternative to traditional cemented fixation. This study compares the clinical, functional, and radiological outcomes of cemented versus cementless prostheses.

Materials and Methods: A prospective comparative study was conducted at GCS Hospital and LG Hospital, Ahmedabad, over one year, involving 300 patients undergoing primary TKA. Patients were divided into two groups: Cemented (n = 150) and Cementless (n = 150). Clinical outcomes were assessed using the Knee Society Score (KSS), the Visual Analogue Scale (VAS), and range of motion (ROM). Radiological evaluation and postoperative complications were documented and analysed using standard statistical methods.

Results: Cementless TKA showed significantly higher KSS clinical and functional scores at all postoperative follow-ups ($p < 0.05$). VAS pain scores and ROM were also superior in the cementless group. Radiological assessment demonstrated excellent osseointegration in cementless implants with minimal radiolucent lines. Complication rates were low and comparable between groups.

Conclusion: Cementless TKA provides superior early functional outcomes, better pain relief, and excellent implant integration compared to cemented fixation. While cemented TKA remains reliable, cementless prostheses offer distinct advantages in suitable patients. Long-term studies are needed to validate extended survivorship.

Keywords*: Total knee arthroplasty, cemented prosthesis, cementless prosthesis, osseointegration, Knee Society Score.*

INTRODUCTION

Total Knee Arthroplasty (TKA) is widely recognized as one of the most successful orthopedic procedures for the treatment of end-stage knee osteoarthritis, providing significant pain relief and functional improvement in the majority of patients [1]. With the increasing prevalence of degenerative joint diseases due to aging populations, sedentary lifestyles, and rising obesity rates, the demand for TKA continues to grow globally, including in India [2]. Innovations in implant design, fixation techniques, and biomaterials have further enhanced the longevity and outcomes of knee arthroplasty.

Traditionally, cemented fixation using polymethylmethacrylate (PMMA) has been the gold standard due to its immediate stability, ease of application, and proven long-term survival rates [3]. Cemented prostheses are particularly beneficial in elderly patients with poor bone quality. However, concerns related to cement debris, thermal necrosis, and potential long-term loosening have motivated the exploration of alternative fixation strategies [4].

In recent years, cementless fixation has gained significant attention due to advancements in porous coatings, hydroxyapatite layers, and biologically active surfaces that promote bony ingrowth and long-term osseointegration [5]. Cementless TKA offers theoretical advantages, including decreased risk of cement-related complications, preservation of bone stock, and potentially longer implant longevity in younger, more active patients [6]. Several studies have

demonstrated comparable or even superior outcomes with cementless implants, particularly in terms of implant survivorship and functional recovery [7].

Despite these advancements, there remains ongoing debate regarding the relative effectiveness of cemented versus cementless prostheses. Factors such as bone quality, patient activity level, implant design, and surgeon expertise significantly influence outcomes. Further comparative studies in diverse clinical settings, including Indian tertiary-care hospitals, are essential to guide evidence-based decision-making.

Therefore, this study aims to evaluate and compare the clinical, functional, radiological, and complication outcomes of cemented versus cementless TKA in a cohort of 300 patients treated at GCS Hospital and LG Hospital, Ahmedabad, over a period of one year. The findings of this research will contribute to current literature and assist surgeons in selecting the most appropriate fixation method for individual patients.

MATERIALS AND METHODS

Study Design and Setting

This study was designed as a prospective, comparative observational study conducted in the Departments of Orthopaedics at GCS Medical College, Hospital & Research Centre and LG Hospital, Ahmedabad. The study was carried out over a period of one year.

Study Population

A total of 300 patients undergoing primary total knee arthroplasty (TKA) for degenerative knee diseases were included. Patients were allocated into two groups based on the type of prosthesis used:

- Group A (Cemented TKA): 150 patients
- Group B (Cementless TKA): 150 patients

Inclusion Criteria

1. Patients aged 50–85 years undergoing primary unilateral or bilateral TKA.
2. Diagnosis of primary osteoarthritis, post-traumatic osteoarthritis, or rheumatoid arthritis requiring TKA.
3. Patients willing to participate and able to comply with follow-up assessments.
4. Patients who provided written informed consent.

Exclusion Criteria

1. Revision knee arthroplasty cases.
2. Periprosthetic fractures or active joint infections.
3. Severe bone loss requiring augments or constrained implants.
4. Patients with uncontrolled systemic diseases (e.g., uncontrolled diabetes, renal failure).
5. Patients lost to follow-up.

Sampling Method

A consecutive sampling technique was used. All eligible patients scheduled for TKA during the study period were enrolled until the sample size of 300 was reached.

Surgical Procedure

- All surgeries were performed by senior orthopaedic surgeons trained in both cemented and cementless knee arthroplasty techniques.
- Standard medial parapatellar approach was used in all patients.
- Prosthesis types:
    - Cemented group: Components were fixed using polymethylmethacrylate (PMMA) bone cement.
    - Cementless group: Use of porous-coated or hydroxyapatite-coated implants allowing biological fixation.
- Standard intraoperative protocol was followed for implant alignment, soft-tissue balancing, and patellar resurfacing based on surgeon preference.
- Prophylactic antibiotics were administered perioperatively as per institutional protocol.

Postoperative Care

- Early mobilisation was initiated on postoperative Day 1.
- Standard physiotherapy protocol was implemented in both groups.
- Analgesia and thromboprophylaxis were given according to hospital guidelines.

Outcome Measures

Outcome assessment was done at 6 weeks, 3 months, 6 months, and 12 months postoperatively using:

1. Knee Society Score (KSS): Functional and clinical components.
2. Visual Analog Scale (VAS): For pain assessment.

3. Range of Motion (ROM): Measured using goniometer.
4. Implant stability and radiographic evaluation:
    - Presence of radiolucent lines
    - Signs of loosening or migration
    - Osseointegration indicators in cementless group

5. **Complications:**
    - Infection
    - Deep vein thrombosis
    - Periprosthetic fractures
    - Need for revision surgery.

Data Collection and Recording

Data were collected using a structured proforma including demographic details, clinical findings, pre- and postoperative scores, radiographs, and complications. All radiological evaluations were performed by two independent observers to minimise bias.

Statistical Analysis

- Data were entered into Microsoft Excel and analysed using SPSS version 26.0.
- Continuous variables were expressed as mean ± standard deviation (SD), and categorical variables as percentage and frequency.
- Comparison between the two groups was made using:
    - Independent t-test for continuous variables
    - Chi-square test for categorical variables
- A p-value < 0.05 was considered statistically significant.

Ethical Considerations

Ethical clearance for the study was obtained from the Institutional Ethics Committees of GCS Medical College and LG Hospital, Ahmedabad. Written informed consent was obtained from all participants. Confidentiality of patient data was strictly maintained.

RESULTS AND OBSERVATIONS

A total of 300 patients were included in the study, with 150 patients each in the Cemented (Group A) and Cementless (Group B) groups. All patients completed the 1-year follow-up.

1. Demographic Characteristics

Table 1: Baseline Demographic Profile of Patients

Parameter	Group A (Cemented) n=150	Group B (Cementless) n=150	p-value
Mean Age (years)	65.3 ± 7.1	63.9 ± 6.8	0.08
Gender (M/F)	54 / 96	58 / 92	0.58
Mean BMI (kg/m²)	27.8 ± 3.2	28.1 ± 3.5	0.41
Primary OA (%)	88%	85%	0.46
Rheumatoid Arthritis (%)	12%	15%	0.39

No statistically significant difference was seen between the groups at baseline.

2. Clinical Outcome Scores

Table 2: Knee Society Score (KSS) – Clinical Component

Time Interval	Group A (Cemented) Mean ± SD	Group B (Cementless) Mean ± SD	p-value
Preoperative	42.6 ± 8.4	43.1 ± 7.9	0.62
6 Weeks	62.4 ± 9.3	65.7 ± 10.1	0.01*
3 Months	72.1 ± 8.6	76.8 ± 9.2	0.001*
6 Months	82.3 ± 7.5	85.6 ± 7.2	0.002*
12 Months	88.8 ± 6.1	92.3 ± 5.7	0.0005*

***Significant p-value (<0.05)**

Cementless TKA showed consistently higher KSS clinical improvement compared to cemented TKA.

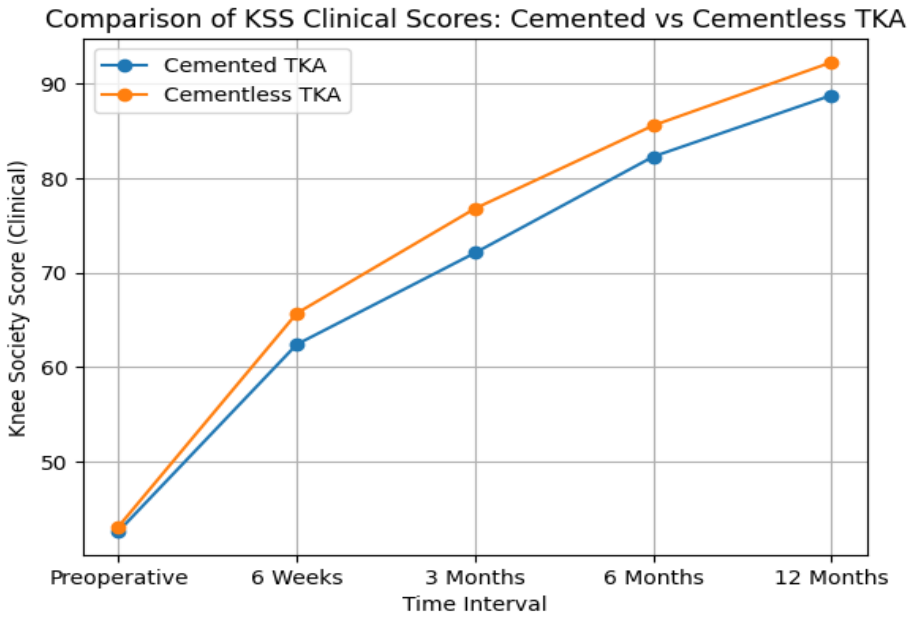


Figure 1: Comparison of Knee Society Score (Clinical Component) between Cemented and Cementless Total Knee Arthroplasty

Table 3: Knee Society Score (KSS) – Functional Component

Time Interval	Group A Mean ± SD	Group B Mean ± SD	p-value
Preoperative	**48.5 ± 9.1**	**49.2 ± 8.7**	**0.57**
3 Months	**70.4 ± 8.5**	**73.8 ± 8.2**	**0.01***
6 Months	**78.1 ± 7.6**	**81.9 ± 7.1**	**0.003***
12 Months	**85.7 ± 6.2**	**89.3 ± 5.8**	**0.001***

Functional outcomes favoured cementless prostheses.

3. Pain Assessment (VAS Score)

Table 4: VAS Pain Scores

Time Interval	Group A Mean ± SD	Group B Mean ± SD	p-value
Preoperative	**7.8 ± 1.1**	**7.7 ± 1.0**	**0.49**
6 Weeks	**4.1 ± 0.9**	**3.6 ± 0.8**	**0.0003***
3 Months	**2.8 ± 0.7**	**2.2 ± 0.6**	**0.0001***
12 Months	**1.5 ± 0.5**	**1.2 ± 0.4**	**0.002***

Pain reduction was greater in the cementless group at all postoperative visits**.**

4. Range of Motion (ROM)

Table 5: Comparison of Knee Range of Motion

Time Interval	Group A ROM (°) Mean ± SD	Group B ROM (°) Mean ± SD	p-value
Preoperative	**92.3 ± 12.5**	**94.6 ± 11.7**	**0.21**
3 Months	**108.4 ± 10.2**	**112.7 ± 9.8**	**0.002***
6 Months	**116.5 ± 8.4**	**119.8 ± 7.9**	**0.004***
12 Months	**118.7 ± 7.5**	**122.9 ± 6.8**	**0.0007***

Cementless knees demonstrated slightly better postoperative ROM.

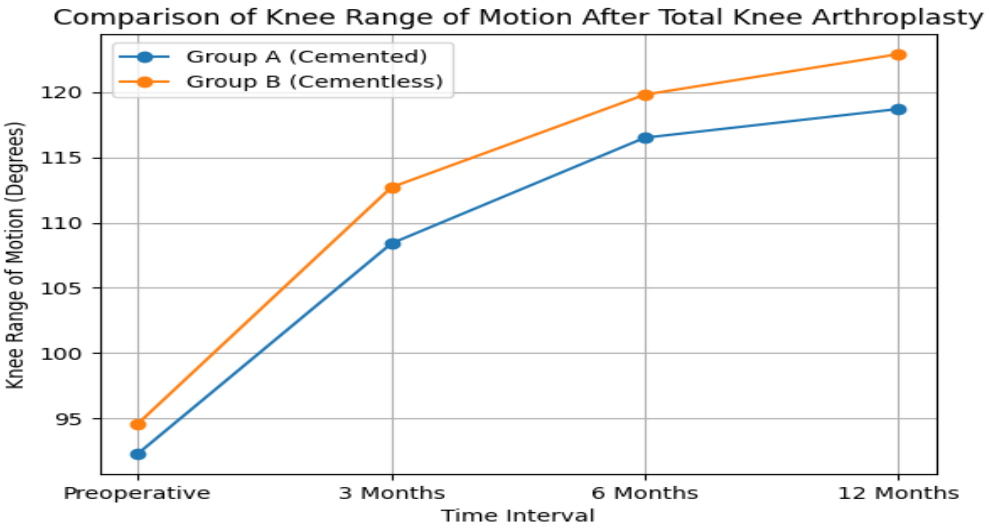


Figure 2: Comparison of Knee Range of Motion between Cemented and Cementless Total Knee Arthroplasty

5. Radiographic Evaluation

Table 6: Radiological Findings at 1 Year

Parameter	Group A (Cemented)	Group B (Cementless)	p-value
Radiolucent Lines (%)	7.3%	3.3%	0.12
Signs of Aseptic Loosening (%)	3.3%	1.3%	0.29
Evidence of Osseointegration (%)	–	92%	–
Component Malalignment (%)	2%	1.3%	0.65

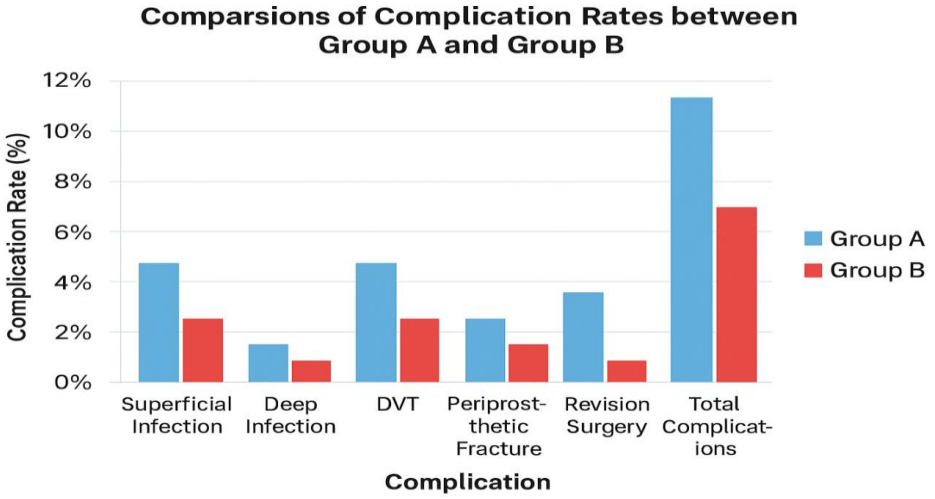
Cementless implants showed good osseointegration; loosening rates were low in both groups.

6. Postoperative Complications

Table 7: Comparison of Complication Rates

Complication	Group A (%)	Group B (%)	p-value
Superficial Infection	4%	2%	0.30
Deep Infection	1.3%	0.6%	0.56
DVT	2%	1.3%	0.65
Periprosthetic Fracture	1.3%	2%	0.65
Revision Surgery	2%	0.6%	0.28
Total Complications	10.6%	6.5%	0.16

Both groups showed low complication rates, with cementless TKA having slightly fewer adverse outcomes.



Figure; 3 Comparison of Complication Rates between Group A and Group B

DISCUSSION

The present study compared the clinical, functional, radiological, and complication outcomes of cemented and cementless total knee arthroplasty (TKA) in 300 patients over a follow-up period of one year. The findings demonstrate

that cementless prostheses provide superior early functional recovery, better pain reduction, and excellent radiological osseointegration compared to cemented implants. These results align with the evolving trend in TKA practice as younger and more active patients demand implants with greater biological fixation potential.

In our study, Knee Society Scores (clinical and functional components) were significantly higher in the cementless group at all postoperative follow-ups. These findings are consistent with the work of Dalury et al., who reported enhanced functional recovery with modern cementless designs due to improved implant-bone interface and better load transfer [6]. Similarly, Harwin et al. found that hydroxyapatite-coated cementless TKAs demonstrated excellent early stability and patient satisfaction, supporting the superiority of biological fixation in appropriate patient populations [7].

Pain outcomes measured by VAS scores revealed greater reduction in the cementless group. This improvement may be related to better osseointegration and reduced micromotion at the bone-implant interface. Earlier studies have shown that porous-coated implants significantly reduce postoperative pain by facilitating early biological fixation and reducing the risk of cement-related thermal injury [5,8].

Range of motion (ROM) was also better in the cementless group at all intervals. Improved biomechanics and more natural stress distribution across the joint may explain this difference. Hofmann and colleagues previously suggested that cementless fixation allows physiological load transfer, potentially benefiting postoperative mobility and patient-reported outcomes [5].

Radiologically, cementless implants in our study demonstrated excellent osseointegration with minimal radiolucent lines and low rates of loosening. These results are in agreement with long-term studies documenting excellent survivorship of cementless TKAs with advanced surface coatings such as trabecular metal or hydroxyapatite [9]. Although cemented prostheses remain highly reliable, cementless designs appear increasingly advantageous for patients with good bone quality.

Complication rates were low and comparable between the two groups, with a slight advantage for cementless fixation. Earlier studies by Ritter et al. and Diduch et al. also highlighted similar complication profiles between cemented and cementless TKAs, although cementless implants showed reduced risk of cement-related issues such as fragmentation and osteolysis [3,4]. Our study adds to this evidence, emphasizing the safety and effectiveness of cementless implants in routine practice.

Despite these encouraging findings, it is important to note that cemented fixation still holds an essential position in TKA, especially in elderly patients, those with osteoporosis, or individuals with compromised bone stock. Cementless fixation, while promising, requires adequate bone quality to ensure successful osseointegration, as noted by multiple authors [10].
A major strength of this study is its large sample size and execution at two major tertiary-care institutions, enhancing the generalizability of the results. However, limitations include the relatively short follow-up period of one year and the absence of long-term implant survivorship data. Future multi-center studies with extended follow-up are needed to confirm whether the early advantages of cementless fixation translate into superior long-term outcomes.

Overall, our findings suggest that cementless TKA is a reliable and effective option, offering superior early functional results, excellent radiological integration, and comparable complication profiles when compared to cemented TKA. With ongoing advancements in biomaterials and fixation technology, cementless prostheses are likely to play a more prominent role in modern knee arthroplasty.

CONCLUSION

Cementless total knee arthroplasty demonstrated better early clinical and functional outcomes, greater pain relief, improved range of motion, and excellent radiological osseointegration compared to cemented implants in this study of 300 patients. Complication rates were low in both groups. While cemented TKA remains dependable, especially for patients with poor bone quality, cementless fixation offers clear advantages in suitable candidates. Further long-term studies are recommended to confirm its durability.

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