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Economical Total Knee Arthroplasty for Severe Varus and Flexion Deformities: A Prospective Cohort Study

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ABSTRACT

Background: Severe combined varus and flexion abnormalities in end-stage osteoarthritis provide a complex indication for total knee arthroplasty (TKA), sometimes necessitating expensive augmentations and specialized implants.

Objective: This research aimed to assess an efficient, economical surgical technique using typical cruciate-sacrificing implants in conjunction with specific soft-tissue releases and autogenous bone grafting.

Patients and methods: A prospective cohort of 20 patients (28 knees) exhibiting sever varus (≥14°) and fixed flexion contracture (≥5°) received cost-effective TKA using a standardized surgical method. Preoperative abnormalities, surgical data, postoperative alignment, range of motion (ROM), knee society clinical and functional ratings, and complications were documented during an average follow-up period of 33 months.

Results: The patients had a mean preoperative varus of 24.9° and a flexion contracture of 17.2°. Bone grafting and the use of tibial stems were required in 25.0% and 10.7% of knees respectively. The average correction of postoperative deformity was 25.8°, achieving a limb alignment of 5.9° valgus. Flexion increased to 117° with little extension losses. The knee society knee and function ratings improved dramatically from 30 to 91 and from 29 to 89 respectively. Functional results were classified as excellent or good in 82.1% of knees. Complications were infrequent, impacting 14.3% of knees.

Conclusion: This economical approach achieved consistent deformity correction, outstanding functional recovery, and minimal complication rates in patients with severe varus and flexion deformities, indicating a feasible alternative to pricier implant-dependent procedures in resource-limited settings.

Keywords: Total knee arthroplasty, Varus deformity, Flexion contracture, Cost-effective surgery, Autograft, Soft tissue release.

INTRODUCTION

Patients with end-stage osteoarthritis exhibiting significant varus and flexion deformities are often recommended for total knee arthroplasty (TKA) as the ultimate therapeutic modality. TKA procedures in these patients are complex due to delayed presentation, which typically results in substantial medial ligament contracture and posterior capsular tightness, causing combined coronal and sagittal malalignment, thereby complicating gap balancing and component positioning [(1)].

Consequently, the use of correction measures in these intricate processes is crucial for attaining comprehensive soft tissue release [(2)]. Traditional corrective measures such as constrained prostheses, long-stem extensions, and metal wedges effectively rectify bone deformities and instabilities. Nevertheless, they may significantly increase procedural costs, rendering them expensive in resource-constrained settings [(3)].

Recent studies suggest that careful soft-tissue procedures may efficiently achieve alignment without necessitating costly enhancements. The progressive release of the medial collateral ligaments, together with posteromedial capsular and osteophyte excision, has resulted in improved and more neutral mechanical axis and symmetrical flexion-extension gaps with just conventional cruciate-sacrificing implants [(4, 5)].

Concurrently, posteromedial tibial deficiencies may be addressed with autogenous bone grafting from femoral or tibial incisions, while cortical screw fixation may facilitate graft integration and provide support for implants [(6)].

In this prospective cohort trial, we aimed to assess an efficient, cost-effective total knee arthroplasty regimen for patients exhibiting significant varus (≥14°) and flexion contracture (≥5°), using standard autogenous knee implants.

PATIENTS AND METHODS

This prospective cohort research was undertaken in the Orthopedic Department at Benha University Hospital from August 2020 to April 2025. This research included 20 patients with 28 knees who had affordable TKA with a standardized protocol developed by the experienced surgeons at our institution with follow-up extending to 24 months post-procedure.

Inclusion criteria: individuals exhibiting end-stage osteoarthritis with a combined varus deformity ≥ 14° and a fixed flexion contracture ≥ 5° as shown in weight-bearing anteroposterior and lateral radiographs.

Exclusion criteria: Patients with inflammatory arthritis, previous knee infections and neuromuscular

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problems, or inadequate bone stock that would prevent routine cemented fixation.

Preoperative assessment: A standardized data collection form was developed to document all pertinent baseline information of the enrolled patients, encompassing demographic details (age & sex), laterality (unilateral & bilateral), deformity metrics (mechanical tibiofemoral varus angle & fixed flexion contracture) and functional status assessed through the Knee Society Clinical Rating System for both knee and function scores.

Surgical technique: All procedures used a medial parapatellar arthrotomy and conventional cemented, cruciate-sacrificing TKA implants.

Key steps:

1. Medial soft-tissue relaxation: Gradual relaxation of the deep followed by the superficial medial collateral ligament (MCL), extending into the posteromedial capsule until tensions in the medial and lateral ligaments were balanced at neutral alignment.

2. Excision of posterior capsular and osteophytes: Resection of posterior femoral osteophytes and alleviation of constricted posterior capsule to rectify flexion contracture.

3. Bone resection: The distal femoral cut was established at 9 mm, then raised to 11 mm when the preoperative flexion contracture surpassed 10° to equilibrate the extension gap with the flexion gap. Conservative tibial excision maintained subchondral bone, with drilling of sclerotic regions to improve cement interdigitation.

4. Management of tibial defects: Posteromedial tibial defects are filled in situ with autogenous bone grafts obtained from femoral or tibial cuts, and fastened with 3.5 mm cortical screws. Tibial stems were used selectively when the graft covered more than 25% of the plateau area. No metallic wedges and augmentations, or limited implants were used.

5. Trialing and implantation: Components for the trial and polyethylene inserts were chosen to provide balanced flexion-extension gaps and coronal stability. The last components were affixed and wound closure according to established guidelines.

Postoperative care and follow-up: A consistent rehabilitation plan was implemented immediately post-surgery, emphasizing weight-bearing as tolerated with continual passive motion. Clinical and radiological evaluations were systematically performed for each patient post-operation, followed by assessments every three months until the conclusion of the follow-up period. Radiographs were used to evaluate mechanical alignment and to identify indications of graft integration, osteolysis, or component loosening.

Outcome measures: The primary objectives were postoperative mechanical axis alignment, range of motion (ROM), knee society knee (KSK) and function scores. Alignment was assessed using the hip–knee–ankle angle on standing radiographs, while range of motion included maximal flexion and extension deficits. Secondary outcomes included the occurrence of graft consolidation, radiographic loosening and osteolysis or complications.

Ethical considerations: This prospective comparative study was approved by The Research Ethics Committee, Faculty of Medicine, Benha University. All patients provided written informed consents prior to participation. The consent form described the study objectives, procedures, potential risks and benefits, the voluntary nature of participation, the right to withdraw at any stage, and permission for the publication of de-identified data and relevant imaging. Confidentiality and privacy were preserved by assigning coded identifiers and restricting data access to the research team. No personal identifiers appear in the study report. The study was carried out in accordance with the ethical principles of the Declaration of Helsinki for research involving human subjects.

Statistical analysis

All statistical analyses were conducted using SPSS version 28 (IBM Inc., Armonk, NY, USA). The variables were descriptively given as mean (range), whereas categorical data were provided as count (percentage). A comparative study was conducted to evaluate pre- and postoperative data regarding alignment, range of motion, and Knee Society ratings, using paired t-tests for analysis. P value ≤ 0.05 was deemed significant.

RESULTS

This research had 20 patients with 28 operated knees, with a mean age of 56 years, ranging from 49 to 64 years. The bulk of the patients were females (13), with just 7 male patients. Bilateral procedures accounted for 40% of the operations, with right-sided surgeries being the more prevalent (16 vs 12). The first assessment of mechanical alignment before to the operation indicated a mean varus deformity of 24.9° (range 16.0–34.4°) and a fixed flexion contracture averaging 17.2° (range 6.3–27.7°). Only 10 knees needed surgical assistance to address tibial abnormalities, with 7 knees having autologous bone grafts and 3 needing tibial stem extensions (Table 1).

Table (1): Baseline preoperative data of the included patients

Parameter	Results
Patient Demographics	
Number of patients	20
Number of knees	28
Age (years)	56.0 (49-64)
Sex (Female/Male)	13/7
Bilateral procedures	8 (40.0%)
Laterality (Right/Left)	16/12
Preoperative Deformities	
Varus deformity (degrees)	24.9 (16.0-34.4)
Flexion contracture (degrees)	17.2 (6.3-27.7)
Surgical Interventions	
Bone graft utilization	7 (25.0%)
Tibial stem utilization	3 (10.7%)

Data is presented either as mean (range) or frequency (percentage).

At the end of the follow-up period, the mean correction of the combined varus and flexion abnormalities was 25.8° (range 15.9–37.5°), resulting in a postoperative alignment of 5.9° valgus (range 4.0–7.2°). The post-operative flexion degree improved to 117°, with an extension deficit of 0–5°. The KSK score increased from 30 (range 16–44) before to the surgery to 91 (range 86–97) subsequent to the treatment. Comparable enhancements were seen in the function scores, which rose from 29 (18–49) to 89 (82–95). According to classification, 11 knees (39.3%) had outstanding results, 12 (42.9%) acceptable, and five (17.9%) fair, resulting in a total success rate (excellent + good) of 82.1%. The total complication rate was infrequent (14.3%), with just two knees exhibiting prolonged inexplicable discomfort and another two demonstrating stiffness. No instances of graft resorption were documented (Table 2).

Table (2): Clinical outcomes of the included patients

Parameter	Result
Follow-up and Alignment	
Total deformity correction (degrees)	25.8 (15.9-37.5)
Postoperative alignment (valgus degrees)	5.9 (4.0-7.2)
Range of Motion Outcomes	
Postoperative flexion (degrees)	117 (96-140)
Extension deficit (degrees)	0-5
Functional Scores	
Preoperative Knee Society Knee Score	30 (16-44)
Postoperative Knee Society Knee Score	91 (86-97)
Preoperative Function Score	29 (18-49)
Postoperative Function Score	89 (82-95)
Functional Categories	
Excellent results	11 (39.3%)
Good results	12 (42.9%)
Fair results	5 (17.9%)
Poor results	0 (0.0%)
Success rate (Excellent + Good)	82.1%
Complications	
Persistent pain	2 (7.1%)
Stiffness	2 (7.1%)
Graft resorption	0 (0.0%)
Overall complication rate	14.3%

Data is presented either as mean (range) or frequency (percentage)

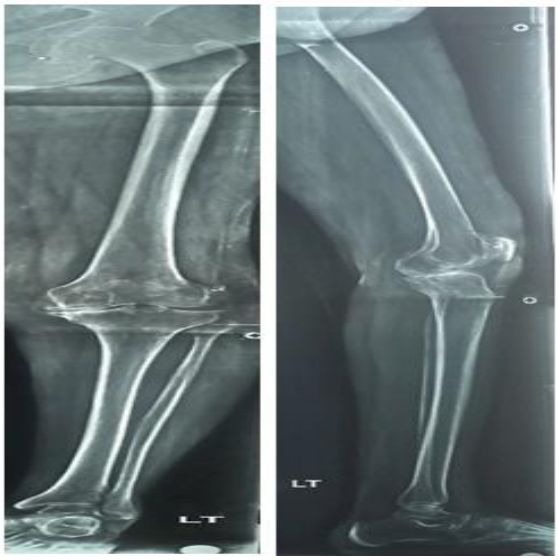

Figure (1): Pre-operative X-Ray.

Figure (2): Pre-operative knee flexion deformity.

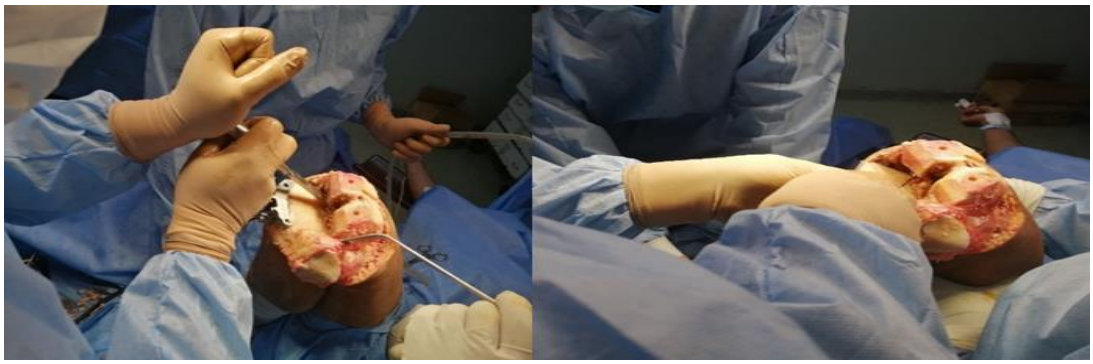

Figure (3): Intra-operative posterior capsule release and osteophyte excision

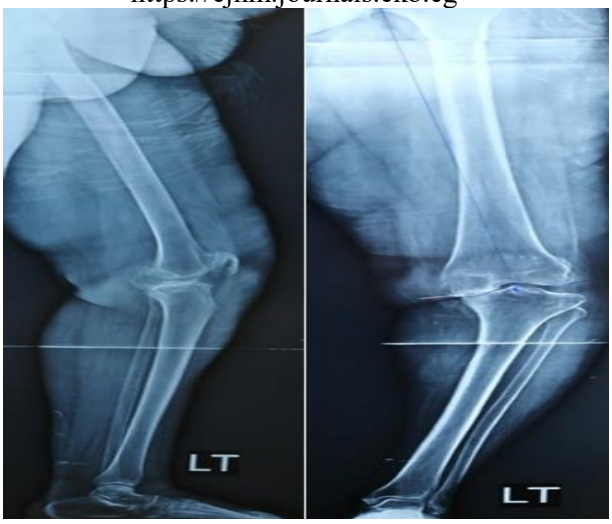

Figure (4): Post-operative X-ray showed full extension.

Figure (5): Post-operative Image showed full extension.

Figure (6): Pre-operative X-ray shows varus deformity and flexion deformity

Figure (7): Pre-operative knee flexion deformity.

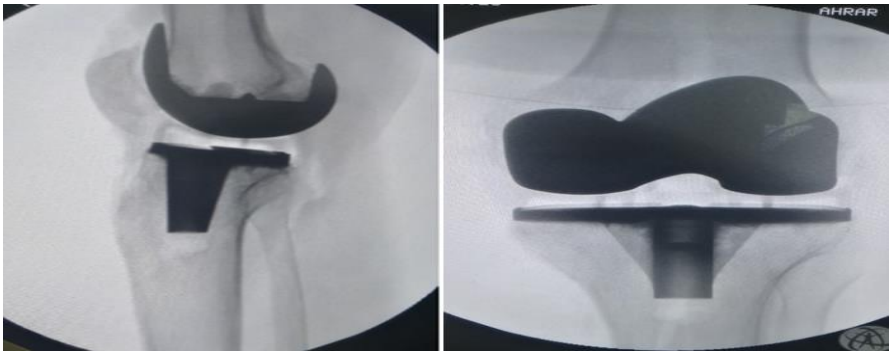

Figure (8): Intra-operative still extension lag.

Figure (9): Intra-operative tibial preparation with med Defect

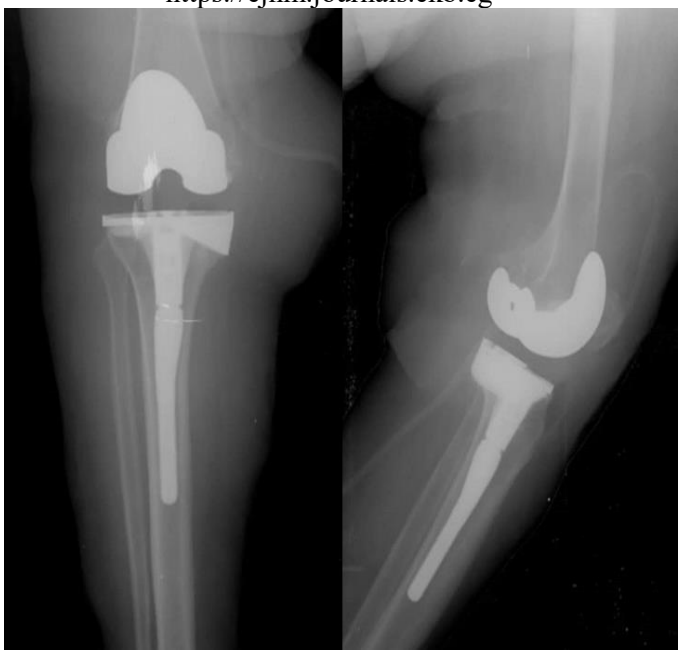

Figure 10. Intraoperative and postoperative radiographs showing full knee extension and proper component positioning. The anteroposterior (left) and lateral (right) views demonstrate satisfactory mechanical alignment and stable fixation following total knee arthroplasty for severe varus and flexion deformity.

DISCUSSION

Despite the significant clinical and economic burden associated with arthritic knees complicated by severe deformities, there is a paucity of longitudinal and prospective studies evaluating the impact of surgical correction on these deformities, with the majority of existing literature relying on small case series or retrospective analyses [7–9]. Consequently, the prospective and observational design of our research contributed to the existing body of information about the selection of suitable treatments for patients with severe deformities recommended for total knee arthroplasty, emphasizing more cost-effective alternatives.

Our research included a substantial cohort of patients (20) with a cumulative total of 28 operated knees. The preoperative deformity severity was significant, with a mean varus angulation of 24.9° and a fixed flexion contracture of 17.2°. The high incidence and severity of knee abnormalities indicated the patients' delayed presentation. This aligns with previous comparable studies that also documented a significant incidence of severe deformity cases attributable to delayed patient presentation. **Bakr *et al.*** [9] examined 30 instances of delayed patients presenting with significant varus and flexion deformities, recommended for TKA.

Our research proved the efficacy of the implemented economic surgical regimen, as postoperative alignment averaged 5.9° valgus, achieving a correction of 25.8°, despite the significant baseline deformity. This aligns with the anatomical aim of 5° valgus suggested by prior research in the literature. This is close to or marginally better than the 5.2° stated in Bakr's initial series [9–11].

Notable enhancements were also seen in the ROM, with the average flexion range rising to 117° and modest extension deficits (0-5°). This aligns with **Bakr *et al.*** [9] 105.1° postoperative flexion. These results underscore the essential function of posterior capsular release and excision of femoral osteophytes in reinstating extension. The improvement in ROM parallels the outcomes from trials using cruciate-retaining designs, suggesting that the preservation of cruciate ligament implants, together the optimization of surrounding soft tissue release, is a potentially effective pragmatic option for severe abnormalities [12].

In relation to the safety analysis of the procedures, the incidence of problems in our research was few. In contrast to our results, treatment with unrestricted TKA in arthritic patients exhibiting severe deformity is often linked to an overall complication risk of 10-15%, with a comparatively elevated risk of significant complications such as MCL laxity or residual instability [13]. This supports the established safety profile of our surgical procedure and the use of biological bone grafts as a secure option to prosthetic implant augmentation.

LIMITATIONS

The limitations of this research were its observational design, which lacks control over confounding variables that may have affected the final findings. The comparatively smaller sample size, reduced follow-up period, and geographical limitations relative to landmark research on knee arthroplasty may influence the generalizability of our results.

CONCLUSION

Severe combined varus and flexion deformities can be corrected using standard cruciate-sacrificing implants, systematic medial soft-tissue release, conservative bone cuts, and selective autografting. This cost-effective technique avoids constrained prostheses and metal augments yet delivers comparable alignment, motion, and patient-reported outcomes, offering a reproducible solution in resource-limited settings.

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Conflicts of Interest: No conflicts of interest.

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