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Original Research Article

Early Functional Recovery Following Total Knee Arthroplasty: Influence of Posterior Condylar Offset Changes in a Prospective Cohort

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Abstract

Background: Posterior condylar offset (PCO) plays an important role in knee biomechanics after total knee arthroplasty (TKA), but its influence on postoperative functional outcomes remains controversial.

Objective: To evaluate changes in posterior condylar offset following primary TKA and determine its association with postoperative knee flexion and functional outcomes.

Methods: This prospective observational study included 40 patients undergoing primary TKA at a tertiary care centre. PCO was measured on standardized lateral radiographs preoperatively and at 3 months postoperatively. Functional outcomes were assessed using knee range of motion and the Knee Society Score (KSS). Appropriate parametric and non-parametric statistical tests were applied, with $p < 0.05$ considered statistically significant.

Results: The mean age of the participants was 62.67 ± 8.44 years, and 65% were female. Mean PCO decreased significantly from 27.16 ± 2.47 mm to 26.34 ± 3.21 mm ($p = 0.012$). Knee flexion improved significantly from 95.10 ± 12.46° to 113.85 ± 13.62°, while the mean total KSS increased from 45.58 ± 7.98 to 79.60 ± 8.10 (both $p < 0.001$). However, changes in PCO were not significantly correlated with postoperative knee flexion ($r = −0.062$, $p = 0.705$) or total KSS ($r = −0.137$, $p = 0.399$). Overall, 92.5% of patients achieved good-to-excellent functional outcomes.

Conclusion: Primary TKA provides excellent early functional recovery. Although PCO changed significantly after surgery, these changes did not significantly influence short-term postoperative knee flexion or functional outcomes.

Keywords: Total knee arthroplasty (TKA), Posterior condylar offset (PCO), Knee Society Score (KSS), Knee flexion, Functional outcomes, Knee biomechanics.

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Introduction

Total knee arthroplasty (TKA) is the gold standard treatment for end-stage knee osteoarthritis and other advanced degenerative knee disorders, providing reliable pain relief, correction of deformity, restoration of function, and improved quality of life [1]. Owing to increasing life expectancy, rising obesity, and the growing prevalence of degenerative joint diseases, the number of TKA procedures performed worldwide continues to increase. Although advances in implant design, surgical techniques, and rehabilitation have substantially improved outcomes, variability in early postoperative functional recovery remains, highlighting the importance of identifying modifiable surgical factors that influence clinical success [2,3].Restoration of normal knee biomechanics is essential for achieving optimal outcomes after TKA. Posterior condylar offset (PCO), defined as the distance between the posterior cortex of the femoral shaft and the most posterior point of the femoral condyles on a true lateral radiograph, is a key anatomical parameter that contributes to posterior femoral rollback during knee flexion [4]. Preservation of PCO facilitates greater knee flexion, maintains flexion stability, and minimizes femorotibial impingement, thereby promoting physiological knee kinematics after arthroplasty [5].During TKA, resection of the distal femur and implantation of the femoral component inevitably

alter the native anatomy of the knee. Inadequate restoration of PCO may reduce posterior femoral rollback, leading to decreased postoperative flexion, flexion instability, and early tibial impingement, whereas excessive restoration may overstuff the flexion gap and increase soft-tissue tension [6,7]. Consequently, restoration of an appropriate PCO has become an important surgical objective to optimize knee biomechanics and functional recovery following TKA [3,5].Early postoperative functional recovery is a major determinant of patient satisfaction after TKA. Adequate knee flexion is essential for performing activities of daily living such as walking, stair climbing, and rising from a chair, squatting, and kneeling. These activities are particularly relevant in the Indian population, where deep knee flexion is frequently required for cultural, occupational, and religious practices [8]. While postoperative recovery is influenced by several factors, including preoperative range of motion, implant design, soft-tissue balancing, and rehabilitation, restoration of PCO remains a surgeon-dependent factor that may significantly affect postoperative function [9].

Despite growing interest in the role of PCO, the relationship between changes in PCO and postoperative functional outcomes remains controversial. Several investigators have demonstrated that preservation of PCO is associated with improved postoperative knee flexion and functional performance, whereas others have reported no significant association between PCO and postoperative range of motion. These conflicting findings may be attributed to differences in implant design, surgical techniques, patient characteristics, and methods used for radiographic assessment [6].Radiographic measurement of PCO using standardized true lateral radiographs is a simple and reproducible method for postoperative assessment. When correlated with validated functional outcome measures such as the Knee Society Score (KSS) and knee range of motion, PCO measurement provides valuable insight into the influence of femoral component positioning on early clinical recovery after TKA [8,10].Evidence regarding the influence of PCO on early functional recovery in the Indian population remains limited. Considering the higher functional demands requiring deep knee flexion and potential anatomical variations, prospective evaluation of PCO restoration and its association with postoperative functional outcomes is warranted. Therefore, the present prospective cohort study was undertaken to evaluate changes in posterior condylar offset following primary total knee arthroplasty and to determine their influence on early functional recovery using knee range of motion and Knee Society Scores.

Materials and Methods

Study Design: This prospective cohort study was conducted to evaluate changes in posterior condylar offset (PCO) following primary total knee arthroplasty (TKA) and to determine their influence on early functional recovery.

Study Setting and Duration: The study was carried out in the Department of Orthopaedics, Sapthagiri Hospital, Sapthagiri Institute of Medical Sciences and Research Centre (SIMSRC), Bengaluru, India, over an 18-month period from May 2024 to October 2025.

Study Participants

Inclusion Criteria

- Patients aged 45–80 years undergoing primary TKA.
- Patients receiving a cruciate-sacrificing total knee prosthesis.
- Patients willing to provide written informed consent.

Exclusion Criteria

- Previous lower limb joint replacement or surgery.
- Associated knee ligament injuries.
- Neurovascular insufficiency of the affected limb.
- Body mass index (BMI) >35 kg/m².
- Inability to ambulate independently.
- Visual disorders affecting gait or balance.

Sampling Technique: Consecutive sampling was used, and all eligible patients were enrolled until the required sample size was achieved.

Surgical Procedure: All patients underwent primary TKA using a standardized surgical technique with a cruciate-sacrificing prosthesis performed by experienced orthopaedic surgeons. Standard perioperative and rehabilitation protocols were followed for all participants.

Outcome Assessment

Radiographic Assessment: Posterior condylar offset (PCO) was measured on standardized true lateral knee radiographs obtained preoperatively and postoperatively. The change in PCO was calculated by comparing preoperative and postoperative measurements.

Clinical Assessment: Functional outcomes were assessed using the Knee Society Score (KSS) and knee flexion measured with a universal goniometer. Assessments were performed preoperatively and at 2 weeks, 1 month, and 3 months after surgery.

Data Collection: Demographic, clinical, operative, radiographic, and follow-up data were prospectively collected using a structured case

record form and entered into Microsoft Excel for analysis.

Statistical Analysis: Data were analyzed using IBM SPSS Statistics. Continuous variables were expressed as mean ± standard deviation or median (interquartile range), while categorical variables were presented as frequencies and percentages. Normality was assessed using the Shapiro–Wilk test. Changes over time were analyzed using paired t-test/Wilcoxon signed-rank test and repeated-measures ANOVA/Friedman test, as appropriate. Correlations between changes in PCO and functional outcomes were assessed using Pearson's correlation coefficient, while categorical variables were compared using the Chi-square or Fisher's exact test. A p value <0.05 was considered statistically significant.

Ethical Considerations: The study was approved by the Institutional Ethics Committee of Sapthagiri Institute of Medical Sciences and Research Centre, Bengaluru. Written informed consent was obtained from all participants, and confidentiality was maintained throughout the study.

Results

A total of 40 patients undergoing primary total knee arthroplasty were included in the study. The mean age of the participants was 62.67 ± 8.44 years (range, 48–79 years). Females constituted the majority of the study population (65.0%, n=26), while males accounted for 35.0% (n=14). Homemakers represented the largest occupational group (35.0%), followed by sedentary workers (22.5%), manual labourers (17.5%), farmers (12.5%), and retired individuals (12.5%) (Table 1A, Figure 1).

Regarding baseline clinical characteristics, the right knee was affected in 50.0% (n=20) of patients, the left knee in 35.0% (n=14), and bilateral involvement was observed in 15.0% (n=6). Osteoarthritis was the predominant indication for surgery (95.0%, n=38), whereas rheumatoid arthritis accounted for 5.0% (n=2). Varus deformity was present in 75.0% (n=30) of patients, while valgus deformity and no deformity were observed in 7.5% (n=3) and 17.5% (n=7), respectively (Table 1B).Spinal anaesthesia was the most commonly used anaesthetic technique (70.0%, n=28), followed by general anaesthesia (20.0%, n=8) and combined spinal anaesthesia with periarticular cocktail (10.0%, n=4). The mean duration of surgery was 94.53 ± 15.64 minutes, and the mean length of hospital stay was 7.78 ± 2.14 days (Table 2A, Figure 2).The mean posterior condylar offset (PCO) decreased significantly from 27.16 ± 2.47 mm preoperatively to 26.34 ± 3.21 mm at 3 months postoperatively, representing a mean reduction of 0.82 ± 1.97 mm ($p = 0.012$). The median PCO changed minimally from 26.70 mm to 26.50 mm, while the range varied from 22.80–32.60 mm preoperatively to 19.60–32.40 mm postoperatively (Table 2B, Figure 3).Significant improvements were observed in all functional outcome measures following surgery. Mean knee flexion improved from 95.10 ± 12.46° preoperatively to 113.85 ± 13.62° at 3 months ($p < 0.001$). Extension deficit decreased significantly from 7.78 ± 3.58° to 3.05 ± 3.36° ($p < 0.001$). Similarly, the mean total Knee Society Score (KSS) improved from 45.58 ± 7.98 to 79.60 ± 8.10 ($p < 0.001$).

Significant improvements were also observed in the KSS pain, stability, and range-of-motion subscores (all $p < 0.001$) (Table 3).Repeated-measures analysis demonstrated significant longitudinal improvement in both knee flexion and total KSS across postoperative follow-up. Repeated-measures ANOVA showed significant changes in knee flexion ($F = 213.2$, $p < 0.001$) and total KSS ($F = 734.1$, $p < 0.001$). These findings were further confirmed by Friedman test results, which also demonstrated statistically significant improvements for knee flexion ($\chi^2 = 104.962$, $p < 0.001$) and total KSS ($\chi^2 = 119.707$, $p < 0.001$) (Table 4).Correlation analysis revealed no significant association between changes in PCO and postoperative functional outcomes. The change in PCO showed a weak negative correlation with knee flexion at 3 months ($r = −0.062$, $p = 0.705$) and with total KSS ($r = −0.137$, $p = 0.399$).

Likewise, no significant correlations were observed between PCO change and knee flexion at 2 weeks ($r = −0.111$, $p = 0.496$) or 1 month ($r = −0.067$, $p = 0.681$) (Table 5).At the final follow-up, 47.5% (n=19) of patients achieved an excellent Knee Society Score, 45.0% (n=18) had good outcomes, and 7.5% (n=3) had fair outcomes; no patient had a poor outcome. There was no significant association between the degree of PCO change and final KSS category (Fisher's exact test, $p = 0.082$). Postoperative wound healing was satisfactory in most patients, with 87.5% (n=35) demonstrating healthy wound status. Wound dehiscence occurred in 7.5% (n=3), while wound discharge and infection were each observed in 2.5% (n=1) of patients (Table 6).

Table 1A: Baseline Demographic Characteristics of the Study Population (N = 40)

Characteristic	Category	n (%) / Mean ± SD
Age (years)	Mean ± SD	62.67 ± 8.44
	Range	48–79
Gender	Female	26 (65.0)
	Male	14 (35.0)
Occupation	Homemaker	14 (35.0)
	Sedentary worker	9 (22.5)
	Manual labourer	7 (17.5)
	Farmer	5 (12.5)
	Retired	5 (12.5)

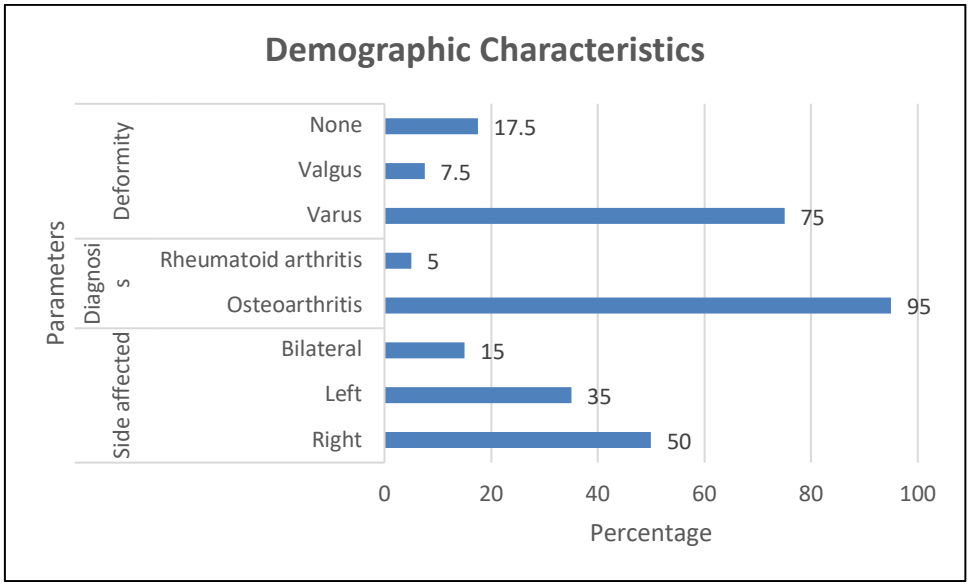

Figure 1: Baseline Demographic Characteristics of the Study Population (N = 40)

Table 1B: Baseline Clinical Characteristics of the Study Population (N = 40)

Characteristic	Category	n (%)
Side affected	Right	20 (50.0)
	Left	14 (35.0)
	Bilateral	6 (15.0)
Diagnosis	Osteoarthritis	38 (95.0)
	Rheumatoid arthritis	2 (5.0)
Deformity	Varus	30 (75.0)
	Valgus	3 (7.5)
	None	7 (17.5)

Table 2 A: Operative Characteristics of the Study Population (N = 40)

Variable	Category	Value
Type of anaesthesia	Spinal anaesthesia	28 (70.0)
	General anaesthesia	8 (20.0)
	Combined (SA + TKR cocktail)	4 (10.0)
Duration of surgery (minutes)	Mean ± SD	94.53 ± 15.64
Hospital stay (days)	Mean ± SD	7.78 ± 2.14

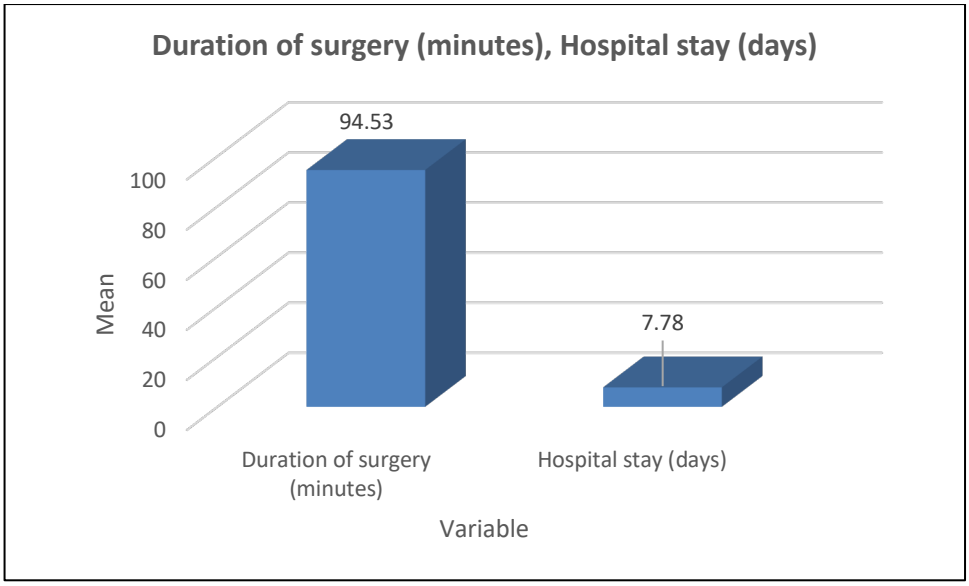

Figure 2: Operative Characteristics of the Study Population (N = 40)

Table 2 B: Posterior Condylar Offset Measurements Before and After Total Knee Arthroplasty (N = 40)

Variable	Preoperative	Postoperative (3 Months)	p value
Mean ± SD (mm)	27.16 ± 2.47	26.34 ± 3.21	0.012
Median (mm)	26.70	26.50	
Range (mm)	22.80–32.60	19.60–32.40	
Mean change (mm)	-	−0.82 ± 1.97	

Paired t-test; p < 0.05 considered statistically significant.

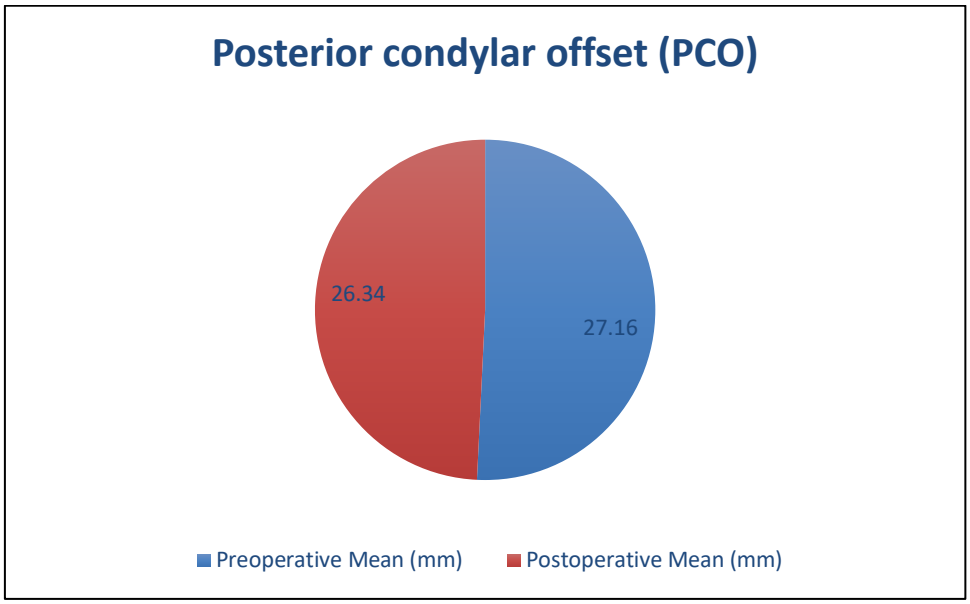

Figure 3: Posterior Condylar Offset Measurements Before and After Total Knee Arthroplasty (N = 40)

Table 3: Comparison of Functional Outcomes before and After Total Knee Arthroplasty (N = 40)

Outcome	Preoperative (Mean ± SD)	3 Months (Mean ± SD)	Test	p value
Knee flexion (°)	95.10 ± 12.46	113.85 ± 13.62	Paired t-test	<0.001
Extension deficit (°)	7.78 ± 3.58	3.05 ± 3.36	Paired t-test	<0.001
Total KSS	45.58 ± 7.98	79.60 ± 8.10	Paired t-test	<0.001
KSS Pain	19.62 ± 5.70	39.92 ± 6.58	Paired t-test	<0.001
KSS Stability	14.30 ± 4.29	20.32 ± 4.18	Paired t-test	<0.001
KSS ROM	11.65 ± 3.25	19.35 ± 3.71	Paired t-test	<0.001

Table 4: Longitudinal Analysis of Functional Outcomes Following Total Knee Arthroplasty (N = 40)

Outcome	Statistical Test	Test Statistic	Degrees of Freedom	p value
Knee flexion	Repeated-measures ANOVA	F = 213.2	3,117	<0.001
Knee flexion	Friedman test	χ^2 = 104.962	3	<0.001
Total KSS	Repeated-measures ANOVA	F = 734.1	3,117	<0.001
Total KSS	Friedman test	χ^2 = 119.707	3	<0.001

Table 5: Correlation between Change in Posterior Condylar Offset and Functional Outcomes (N = 40)

Variable	Pearson's r	95% CI	p value
PCO change vs Knee flexion (3 months)	−0.062	−0.366 to 0.255	0.705
PCO change vs Total KSS	−0.137	−0.430 to 0.182	0.399
PCO change vs Flexion (2 weeks)	−0.111	—	0.496
PCO change vs Flexion (1 month)	−0.067	—	0.681
PCO change vs Flexion (3 months)	−0.062	—	0.705

Table 6: Postoperative Functional Outcomes and Complications (N = 40)

Variable	Category	n (%) / Result
Knee Society Score Grade	Excellent	19 (47.5)
	Good	18 (45.0)
	Fair	3 (7.5)
	Poor	0 (0.0)
Association of PCO change with KSS outcome	Fisher's exact test	p = 0.082
Postoperative wound status	Healthy	35 (87.5)
	Dehiscence	3 (7.5)
	Discharge	1 (2.5)
	Infection	1 (2.5)

Discussion

In the present study, the mean posterior condylar offset (PCO) decreased significantly from 27.16 ± 2.47 mm preoperatively to 26.34 ± 3.21 mm at 3 months postoperatively, with a mean reduction of 0.82 ± 1.97 mm (p=0.012). Although the reduction was statistically significant, 40.0% of patients maintained PCO within ±1 mm, indicating satisfactory restoration in the majority of cases. Hanratty et al. [12] evaluated 69 patients undergoing cruciate-sacrificing mobile-bearing TKA and reported that the mean PCO increased from 25.9 mm preoperatively to 26.9 mm postoperatively. However, they found no significant correlation between changes in PCO and postoperative knee flexion (r = −0.06, p = 0.69), concluding that restoration of PCO alone did not predict postoperative flexion.

These findings are comparable with the present study, where no significant relationship was observed between change in PCO and postoperative knee flexion (r = −0.062, p = 0.705).Bauer et al. [13] prospectively analyzed 410 consecutive cruciate-sacrificing mobile-bearing TKAs and observed that postoperative knee flexion was influenced predominantly by preoperative flexion, while changes in PCO showed no independent association with final knee flexion. Their findings support the results of the present study, which also demonstrated significant improvement in knee flexion (95.10 ± 12.46° to 113.85 ± 13.62°, p<0.001) despite the absence of a significant correlation between PCO restoration and flexion. In the present study, the mean total Knee Society Score (KSS) improved significantly from 45.58 ± 7.98 preoperatively to 79.60 ± 8.10 at 3 months (p<0.001). Furthermore, 92.5% of patients achieved good-to-excellent functional outcomes. However, no significant association was found between changes in PCO and improvement in KSS (r = −0.137, p = 0.399).Kane et al. [14] evaluated functional outcomes following TKA and reported significant improvements in pain relief, walking ability, and overall functional status after surgery. Their study demonstrated that TKA provides excellent clinical improvement irrespective of small radiographic variations, which is consistent with the present findings where substantial functional improvement occurred despite modest reductions in PCO.The present study demonstrated a statistically significant reduction in PCO following TKA based on standardized lateral radiographs. Nevertheless, this radiographic change did not translate into poorer clinical outcomes. Clarke [15] suggested that changes in posterior condylar offset cannot be accurately determined using plain radiographs alone because component rotation and projection errors may influence measurements. Therefore, small radiographic changes should be interpreted cautiously and correlated with clinical outcomes. Similarly, Lee and Lee [16] demonstrated that the femoral referencing system influences

postoperative PCO restoration and anterior flange–bone contact. They emphasized meticulous femoral component positioning to optimize knee biomechanics.

Although the present study observed a modest reduction in PCO, postoperative functional recovery remained excellent, indicating that minor changes in PCO may not adversely affect early clinical outcomes when appropriate surgical technique is employed.

Conclusion

Total knee arthroplasty resulted in significant improvements in knee flexion, Knee Society Score, pain relief, and overall functional outcome during the early postoperative period.

Although posterior condylar offset decreased significantly after surgery, its change was not significantly correlated with postoperative knee flexion or functional recovery. These findings suggest that minor variations in posterior condylar offset restoration do not adversely influence short-term clinical outcomes following primary total knee arthroplasty.

Limitations

The study was limited by its relatively small sample size, single-centre design, and short follow-up period of three months, which may limit the generalizability of the findings. Long-term multicentre studies with larger cohorts are required to determine the influence of posterior condylar offset on implant survivorship and long-term functional outcomes.

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