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ORIGINAL ARTICLE

Functional and Cost Audit of Primary Total Knee Arthroplasty in Public vs Private Hospitals: A Retrospective Cohort Study

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Abstract

Background Government funded hospitals are believed to be stigmatised with 'substandard care' and constant fear of infection. The aim of this study is to compare the results and direct expenditure incurred for total knee arthroplasty (TKA) done at a government funded public teaching hospital with an economy packaged private hospital in India.

Materials and Methods A review of electronic and physical records of the patients operated by the senior author for primary TKA at a government funded hospital and a private hospital spanning 2007 to 2019 was done. A retrospective cohort study was designed matching the implant design and the ASA grade of the patients. Knee injury and Osteoarthritis Outcome Score (KOOS), Hospital for Special Surgery score (HSS), Knee Society Score (KSS) at 2 years follow-up were the primary outcome parameters. The retrieved data describing the cost of surgery and perioperative complications were analyzed. The confounders were minimized by including only the surgeries performed by the author, using the same instruments and implants in similar operating theatre environments.

Results This study involved two cohorts comprising 280 patients each, with no differences in gender, ASA grade and primary diagnosis. There was no significant difference in the 2-year HSS, KSS and KOOS score between the two groups. The 2-year cumulative incidence of major and minor complications in both the study cohorts showed no significant difference. The mean cost of an uncomplicated primary TKA (2019) in government hospital was INR. 85,927; 39.476% of that required in a private setup (INR. 2,17,667).

Conclusion Affordable TKA package in a government funded hospital can produce results comparable to that in a private hospital setup at a reasonably lower cost without increasing the complication rates.

Keywords Knee arthroplasty · Cost comparisons · Out-of-pocket expenditure · Grants and subsidies · Government · Corporate practice · Clinical pathways

Introduction

According to a survey by Frost and Sullivan, almost 70,000 joint replacement surgeries were performed in India in 1 year [1]. Yet, it is estimated that the country still has four crore people with non-salvageable tricompartmental osteoarthritis (OA) who need total knee arthroplasty (TKA) for their knee problems, imposing a huge healthcare burden on the country. The gap between the performed surgeries and the unmet need points towards a 'supply side challenge'.

TKA has produced excellent results in terms of restoration of function and quality of life but the 'Direct patient expenditure' involved in the surgery is still high and not affordable to all. Of the 15 to 20 million disabled patients in India who would benefit from TKA, only 1,00,000 to 1,50,000 can afford it [2]. There is a wide difference in the cost of an uninsured, direct patient-paid TKA between public and private hospitals in India. Despite the high turnover rate, the authors believe that the replacement surgeries done in public hospitals in India are often stigmatized to have poor facilities and higher rates of infection.

There is paucity of existing literature studying the effect of varying cost structure, payment methods and operative

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setups on the clinical outcomes and complications. A French hospital study revealed a disproportionately higher number of prosthetic joint infection (PJI) in the public sector hospitals as compared to the private [3]. Katz et al. studied the hospital and surgeon factors behind the outcomes of TKA and concluded better outcomes of surgeries performed in higher volume centres by higher volume surgeons [4]. Runner et al. found a significant reduction in the incidence of PJI transitioning from a multi-speciality surgical hospital to a dedicated orthopaedic hospital [5]. Exploring the role of payment methods, Kurtz et al. found a higher incidence of deep PJI in patients receiving public assistance for Medicare premium [6]. Barrack et al. found a co-relation between lower socio-economic status and poor functional outcomes [7].

There are no existing studies comparing the outcome and complication rates of TKA in hospital setups differing in payment assistance and subsidies. The aim of this study is to audit and present a cost analysis report of '*direct patient expenditure*' incurred for a TKA and to compare the outcomes of a group of patients operated in a government aided public teaching hospital with an economically packaged private hospital setup in a metropolitan city operated by a single surgeon using similar implants, operative and post-operative protocols.

Materials and Methods

This is a retrospective observational study comparing clinical outcomes and complication rates between two cohorts of patients operated for primary TKA from January 2007 to October 2019. The surgeries have been carried out by the same surgeon (first author) in both the cohorts using identical predefined set of '*Clinical Care Pathways*'. These '*Clinical Care Pathways*' encompass set protocols for preoperative optimization, intraoperative and post-operative management designed by the senior author after suitably modifying the existing protocols in the field knee and spine surgeries [8–10] (Table 1). Patients in both the groups were subjected to these protocols to ensure uniformity. These patients were operated by a standard mid-vastus approach under spinal anesthesia, tourniquet control with an additional adductor canal block for post-operative

Table 1 Clinical care pathways designed by the senior surgeon for all the total knee arthroplasty cases

Clinical care pathways
(A) Preoperative
(i) Screening-Serum Albumin level > 3.5 g/dl
(ii) Strict glycemic control. RBS < 150 mg/dl, HbA1c < 7.0%
(iii) Screening for urinary and dental infection
(iv) Body bathe using Chlorhexidine di-gluconate scrub (0.02 mg in 1 ml) for 5 consecutive days before elective surgery
(v) Skin scrubbing twice using povidone iodine scrub (7.5%w/v)- On the night before surgery and the morning of the surgery
(vi) Hair clipping on the night before surgery
(B) Intra-operative
(i) Sealing the operative room doors with the beginning of surgical incision till the end of closure
(ii) Limiting the operating room traffic to the maximum of 2 anesthetist, 3 Surgeons, 1 Staff nurse, 2 Helping staff
(i) Injectable antibiotics 30 min prior to tourniquet inflation
Inj. Cefuroxime 1.5gm Intravenous
Inj. Amikacin- 750 mg Intravenous
Inj. Vancomycin 1gm Intravenous- only to high risk individuals
(ii) Tourniquet application at the thigh with a pressure of 280 mm hg for a maximum of 2 h
(iii) Skin preparation—Povidone iodine scrub(7.5%), alcohol and povidone iodine solution
(iv) Use of Disposable waterproof drapes and Iodine impregnated incision drape
(v) Pulsatile lavage prior to cementation and implantation
(vi) Perioperative infiltration of analgesic and haemostatic cocktail
(vii) Use of 40gm Medium viscosity antibiotic free bone cement
(viii) Layered closure under Vacuum drain
(C) Post-operative Protocol
(i) Sterile bedsheets
(ii) Avoidance of urinary catheter (unless patient is incontinent/retention)
(iii) Same day mobilization
(iv) Removal of drain at 48 h

analgesia. Standard instruments and techniques were used during the surgery and all the patients were mobilized within 6 h with a 4-legged walker. Packed cell transfusion was reserved for hemoglobin less than 9 g/dl. Patients were monitored for complications and uncomplicated cases were discharged on the fifth post-op day.

The audit was carried out after approval from the Institutional Review Board. (IECIIIOUT/128/2019-dated-16/12/2019) of the government and (ECBHR/OA-08/20) of the private hospital setup.

Only the patients operated for primary unilateral or bilateral sequential TKA were included in the study. For neutralizing the effect of different implant designs on the results, only patients operated with following implants– (a) P.F.C. Sigma, (b) Sigma Monoblock All polyethylene, (c) ATTUNE® Knee System (DePuy, Inc, Warsaw, IN) were included. Patients covered under any insurance schemes, patients operated for post infective or post-hemophilic arthritis, those lost to follow-up and those with follow-up of lesser than 6 months were excluded from the study. Baseline demographic data, indoor details, physical status classification grade (American society of Anesthesiologists-ASA), billings and follow-up of all the patients were extracted from the hospital and the surgeon's repository.

Patients operated in the government hospital (GH) were included in the first cohort (Fig. 1). Those operated by the same senior author in the economy budget private corporate hospital (PCH) were included in the second cohort. Both the hospitals were multi-specialty surgical hospitals with comparable wards, intensive care unit (ICU) facility and dedicated sterile operative rooms equipped with laminar air flow for clean orthopaedic procedures. The participants of both the cohorts were closely matched to minimize the confounders of comorbidity (ASA grade) and implant designs.

Primary Outcome Variables: Clinical and Functional Outcome

The 2 year-outcome data of the patients were retrieved from the surgeon's clinical follow-up notes which included objective outcome scores- Knee society knee score and functional scores (KSS), Hospital for special surgery (HSS) scores and the subjective- patient reported measure

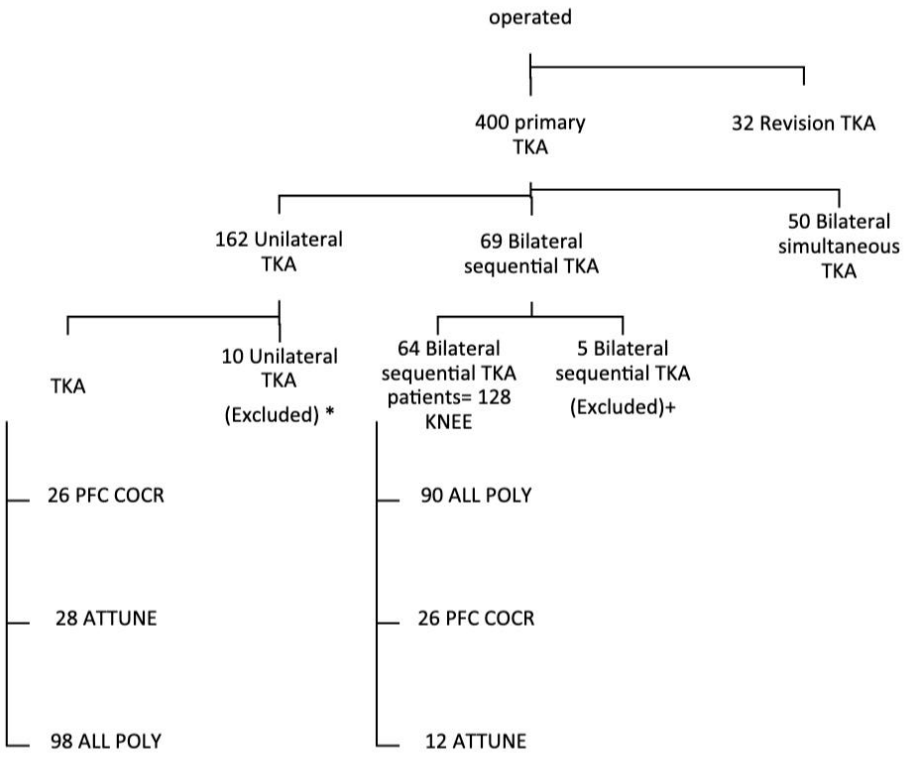

Fig. 1 Recruitment of patients in cohort 1: Government funded teaching hospital

+ Excluded patients on the basis of the exclusion criteria- bilateral simultaneous total knee arthroplasty or operated post infection, arthrodesis.

of Knee injury and Osteoarthritis Outcome Score (KOOS). KOOS, a questionnaire based patient reported outcome scoring comprising of 5 dimensions [11, 12] had been filled by all the participants at a minimum 2 years of follow-up.

Secondary Outcome Variables

Major complications like acute post-operative prosthetic joint infection (PJI), post-operative hematoma retention needing evacuation and delayed chronic infection; and the minor complications like urinary tract infection, respiratory infection, deep vein thrombosis and peroneal nerve palsy were noted from the patient's in-patient and follow-up notes.

For the purpose of this study, only the direct costs incurred during the surgery and those related to complications limited to operative hospital stay were included in the analysis. The 'Direct patient expenditure' data was retrieved from four reliable sources: (1) Surgeon's records; (2) Records and billings from the implant distributor/hospital; (3) Telephonic and personal interviews with the patients; 4) Records from the institutional medical store. Physical billing evidences, hospital and medical store records were taken as superior evidences as compared to surgeon's records and patient interviews in case of conflicts in the reported costs.

The expense for transportation, preoperative radiological and hematological investigations, out-patient consultation, other personal expenses and losses due to the period of disability were not included in the analysis.

Statistical Analysis

Statistical analyses was performed using Microsoft Excel 2019 and SPSS Statistics 19. Descriptive statistics like mean, standard deviation and proportions were used for the baseline demographic data. The categorical variables were tested by Chi-square test. As the outcomes were scored between 0 and 100, they were treated as continuous data. Though the variables of interest (outcomes and complications) were continuous, their normality was tested using Kolmogorov–Smirnov (K-S) goodness of fit test. Independent t test was used to test the differences in the means of the two study cohorts as the variables were normally distributed. All the tests for significance were two tailed and conducted at the 0.05 significance level. A null hypothesis 'No significant difference in the means of the two groups' was tested by statistical means at 95% confidence interval.

A minimal sample size of 170 each in both the cohorts was calculated to be the minimum number to detect a difference of 3 points in the HSS score between the two cohorts, considering two sided significance level of 95 and power of 80% [13].

Table 2 Patient baseline information

Patient characteristics		Public teaching hospital $n=280$	%	Private hospital $n=280$	%	P value
Gender	F:M	3.375:1		3:1		0.5532
Diagnosis	Primary OA	227	81.07%	219	78.21%	0.4011
	RA	49	17.50%	51	18.21%	0.8265
	Others	4	1.42%%	10	3.57%	0.1032
Sides operated	Unilateral	112	40%	124	44.28%	0.3055
	Bilateral	84	60%	78	55.71%	0.3044
Side of surgery	L:R	131:149		124:156		
Implant preference	P.F.C COCR	52	18.57%	55	19.64%	0.7476
	ATTUNE	40	14.28%	46	16.42%	0.4828
	ALL POLY	188	67.14%	179	63.92%	0.4232
ASA Grade						
	ASA I	3	1.07%	4	1.42%	0.7090
	ASA II	140	50%	141	50.35%	0.9340
	ASA III	126	45%	124	44.28%	0.8641
	ASA IV	11	3.92%	11	4.28%	0.8301

F Female, *M* Male, *OA* Osteoarthritis, *RA* Rheumatoid arthritis, *L* Left, *R* Right, *COCR* Cobalt-Chromium, *ASA* American society of Anesthesiologists physical status classification

Results

In total, 280 patients from each study cohort operated for primary TKA between January 2007 and October 2019 were recruited in the study. The participants of both cohorts were comparable for gender, affected sides, primary etiology and ASA grade (Table 2). Large proportion of patients belonged to ASA II (50% in GH vs 50.35% in PCH, $p=0.93$) and ASA III classes (45% vs 44.28%, $p=0.86$). Sigma Monoblock All-polyethylene was the predominantly used implant (67.14% vs 63.92%, $p=0.4232$), followed by P.F.C Sigma Co-Cr (18.57% vs 19.64%) and ATTUNE (14.28% vs 16.42%) across both the groups (Table 2). The mean maximum follow-up of patients in the GH cohort was 3 years and 4 months and that in PCH was 3 years and 2 months.

Patient Reported Outcome Measure: KOOS score

At 2 years follow-up, the mean KOOS score improved in both the groups. In the GH group, the mean KOOS score for pain was 81.64(SD = 18.5), symptoms 80.32 (SD = 10.36), activities of daily life function 79.42(SD = 16.5), sports and recreation function 62.66 (SD 23.2), and quality of life 70.82 (SD = 26.2). In the PCH, the mean KOOS scores for pain was 83.33 (SD = 20.5), symptoms 82.46 (SD = 16.32), activities of daily life function 78.44 (SD = 15.5), sports and recreation function 63.24 (SD = 28.2), quality of life 71.46 (SD = 25.6). No significant difference was observed in the patient reported KOOS scores between the two study cohorts (Fig. 2a).

Knee Society Scores and Hospital for Special Surgery Scores

At 2 years follow-up, both the KSS and HSS scores showed improvement when compared to their pre-operative state (Fig. 2b-d). The mean scores of both the cohorts did not show any statistically significant difference (Table 3).

Complications

Six patients (2.14%) from GH had sterile retained hematoma requiring evacuation as compared to 7 patients (2.50%) in the PCH. 3 patients (1.07%) in both the cohorts had acute PJI requiring debridement, antibiotics and implant retention (DAIR) procedure and one patient each who required two stage revision for chronic PJI (0.33%). Urinary tract infection was associated with catheterization and needed a general physician consultation and antibiotics. The presence of urinary tract infection did not affect the patient's hospital stay or mobilization and were successfully treated with sensitive antibiotics. Two patients in GH and one in PCH developed deep vein thrombosis. These were treated with low molecular weight heparin and warfarin subsequently. None of the patient had pulmonary embolism or any other serious complications. Two patients in private hospital setup developed transient foot drop after correction of fixed valgus deformities. The presence of neurological deficit did not affect the primary hospital stay and all of them were treated conservatively (Table 4).

Cost Audit

Patients of both the cohorts paid for their implants and consumables. Analysis of the implant cost for the years 2007–2017 revealed a standardized mean difference (SMD) of INR. 7000 in the distributor cost of implants in both the hospital setups for P.F.C. COCR and Sigma Monoblock All-polyethylene implants and up-to INR. 40,000 for high-end costing implants like ATTUNE. However, in the post National pharmaceutical pricing authority (NPPA) era (2017 onwards), the price cap had neutralized the difference in implant cost across the hospitals.

On analysis of the non-implant costs, the mean cost of consumable items in GH was significantly lesser as compared to the maximum retail price. The operating room and bed charges covering the entire hospital stay were INR. 300 only from 2007 to 2017and INR. 500 thereafter. The patients were shielded from the professional charges of the surgeon, assistants, physiotherapists and the ancillary staff by the government and no direct cost was incurred by the patient for the surgery.

In contrast, the private hospital provided a fixed rate package for TKA comprising of 5 days of hospital stay, consumables, operative room time, basic diagnostic tests, professional charges of the operating surgeon, assistants, nursing and hospital staff for INR. 1,54,000. An average additional amount of INR. 8000 for blood & blood products or referral for medical opinion or intensive care admission, etc., was borne by the majority of patients.

Cost Comparison

The mean total cost of TKA in GH and PCH was INR. 1,18,160 and INR. 2,57,000 respectively with a SMD of INR. 1,38.840 for the years 2007–2017. After the implant price cap, from 2017 to 2019, the mean total cost was INR. 78,753 and INR. 2,10,933 respectively with a SMD of INR. 1,32,180 (C. I = 95%). (Tables 5, 6; Figs. 3a, b, 4a, b) In GH, the non-implant cost contributed to 21.86% and 37.87% of the total surgical costs between 2007–2017 and 2017–2019 respectively in contrast to 53.70% and 76.80% in PCH (Fig. 5).

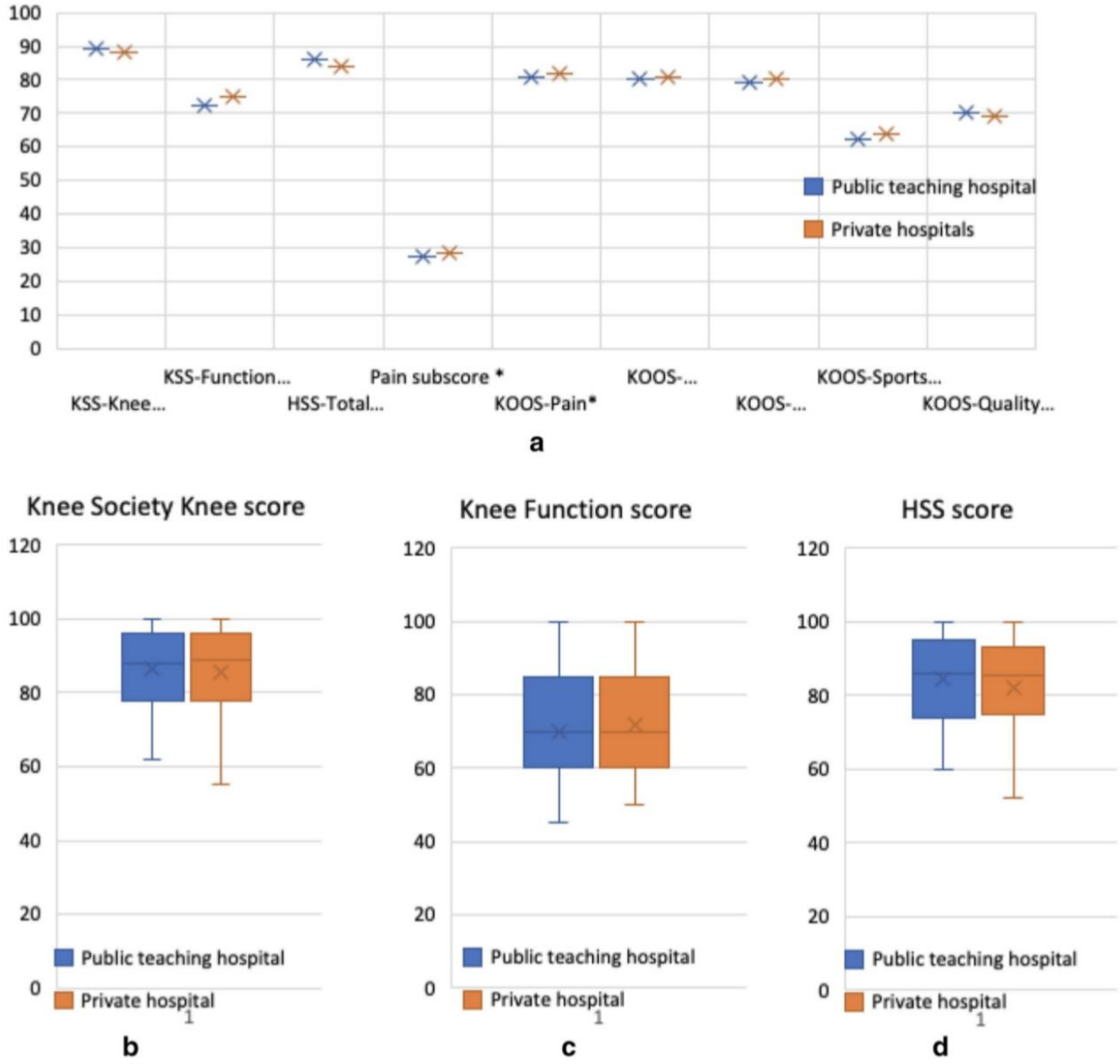

Fig. 2 **a** Mean functional scores- KOOS score. **b–d** Comparison of KSS and HSS Scores between two cohorts

Cost of Complications

The costs associated with respective complications changed over the period of study duration. The variables determining the cost included, prolongation of hospital stay, physician consultation, special investigations and drugs. Procedures needing additional surgical procedure in terms of debridement, liner exchange or revision had significant difference in the cost in both the hospital setup. A 2 staged revision would cost INR. 2,80,000 in a private hospital setup as compared to INR. 1,40,000 in the government hospital setup (Table 4).

Discussion

In a low-to-middle-income country like India, with a large burden of advanced knee arthritis, cost becomes a major limiting factor for patients seeking a TKA. A French hospital study revealed a disproportionately higher number of prosthetic joint infection (PJI) in the public sector hospitals as compared to the private hospitals [3]. Government funded institutions are often believed to provide 'substandard care' with a constant fear of infection. This study compared the results and direct expenditure incurred for total knee arthroplasty (TKA) done at a government

Table 3 Functional outcome in terms of Knee society score, HSS score and KOOS score

Results in Public vs Private					
Knee society scoring system	Public teaching hospital	SD	Private hospital	SD	p value + (unpaired t test)
Knee score*	86.46 (62 to 100)	10.64	85.32 (50 to 100)	9.86	0.189
Function score*	69.89 (45 to 100)	15.35	71.86 (50 to 100)	16.94	0.1499
Hospital for special surgery Score	Public teaching hospital	SD	Private hospital	SD	p value +
Total score*	84.47 (60 to 100)	11.85	83.44 (50 to 100)	14.44	0.3566
Pain sub score *	27.4	5.5	28.2	10	0.2413
KOOS Score	Public teaching hospital	SD	Private hospital	SD	p value +
Pain*	81.64	18.5	83.33	20.5	0.3062
Symptoms*	80.32	10.36	82.46	16.32	0.0645
Activities of daily life*	79.42	16.5	78.44	15.5	0.4691
Sports and recreation function*	62.66	23.2	63.24	28.2	0.7905
Quality of life*	70.82	26.2	71.46	25.6	0.7701

*Represents mean value of the score. The range is mentioned in the brackets

+Unpaired t test

funded public teaching hospital with an economy packaged private hospital.

Our study revealed comparable good functional outcomes in both the government as well as private sector hospitals when the same clinical care pathways were strictly adhered to. The clinical care pathways took into consideration preoperative optimization of clinical status, intraoperative and post-operative aseptic measures.

Preoperative nutritional and comorbidity correction were the two deciding factors to time the surgery. The importance of these factors has also been highlighted in a number of other studies, as important determinants of outcome and satisfaction following TKA [7, 14, 15].

Intra-operatively, the importance of standard operative room practices to reduce incidences of periprosthetic infection have been highlighted in the international consensus on PJI (2018) [10]. The 'Clinical care pathways' practised by the senior author, a member of the international consensus group, involved protocols to reduce the number of door openings, limitation of operative room traffic and sealing of the operative room between the incision and closure. Panahi et al. studied the need for preoperative planing to reduce the number of door openings in total joint arthroplasty [16]. Besides, practising the use of disposable waterproof drapings, trolley covers, iodine impregnated drapes [17], frequent use of low pressure pulsatile lavage [18] had supporting contemporay evidence to reduce PJI and increase longevity of TKA.

Our audit revealed that despite identical functional outcomes in both the groups, there was a significant difference in the total cost incurred for the surgery.

Implant and non-implant related costs form the two branches of the major surgical expense associated with a TKA surgery. Though, the patients in both the cohorts paid 'out of pocket' for the implants and the non-implant related costs for TKA, the cost for achieving equivalent results in the government funded hospital was INR 85,927, approximately 60.60% lesser than the average minimum cost of INR. 2,17,667 in the private hospital setup.

According to *Gui* et al., the implant cost accounted to approximately 65% of the total TKA expenses [19] which is similar to that in the government hospital in our study. However, our study showed that the implant cost only comprised 25.57% of the total surgical cost in the private hospitals with 74.42% being non-implant related.

The patients in the government funded hospitals are shielded from the costs involved in the professional fees of the surgeons, assistants, physiotherapists and hospital administration which form a major component of the private hospital billings. The hospital stay and operative costs are negligible in the government funded hospitals. The government hospitals are thus capable of performing a primary total knee arthroplasty surgery at a net 'sub-one-lakh' cost with results equivalent to the private hospitals.

Why the Cost Difference?

Imported implants form a major market share of the implant market in India. With the inclusion of the knee implants into the category of 'drugs', National Pharmaceutical Pricing Authority (NPPA) has authorized the regulation of its prices

Table 4 Incidence and cost of complications demanding a 2nd surgery in both the cohorts

	Public hospital ($n=280$)	%	Private hospital ($n=280$)	%	p value (Chi-square)	Odd's Ratio (OR)
Hematoma evacuation	6	2.14%	7	2.50%	0.7774	OR = 0.8540
Acute post-operative infection	3	1.07%	3	1.07%	1	OR = 1
2 Staged revision	1	0.33%	1	0.33%	1	OR = 1
Urinary tract infection	12	4.28%	6	2.14%	0.1586	OR = 2.0448
Chest infection	5	1.78%	4	1.42%	0.7374	OR = 1.2545
Deep vein thrombosis	2	0.71%	1	0.35%	0.5704	OR = 2.0072
Peroneal nerve palsy	0	0%	2	0.71%	0.2974	OR = 0.1986
			$P<0.05$-significant			

Approximate Cost associated with complications: As on 2019		
	Public hospital	Private hospital
Hematoma Evacuation	INR 4200	INR 22,000
DAIR = Acute infection	INR 21,000	INR 52,000
2 staged Revision	INR 1,40,000	INR 2,80,000
Urinary tract infection (Consultation and antibiotics)	INR 0	INR 12,000
Deep vein thrombosis	INR 2000	INR 16,000
Peroneal palsy (Conservative treatment and steroids)	INR 0	INR 500

DAIR debridement, antibiotics and implant retention

to make it affordable to all [20]. The cap on the implant cost has brought down the cost of the implant by 65%. However, the reduction in the cost of implants has not been effectively translated into lesser cost for the patients in the private sector. Inflation of the 'non implant' related costs is one of the major reasons behind it. Consumer price index (CPI), a major inflation indicator in India [21] has risen from 100 (2012) to 146.3 (2019) indicating a net increase of 46.3% over a period of 7 years. Inflation does play an important role

Table 5 Cost audit of 'Direct patient expenditure' for TKA surgery in a government funded teaching hospital

Government Hospital		Implant cost (INR.)	Average Disposable cost (INR.)	Hospital Charges (INR.)	Total cost (INR.)	% contribution by Implant	% Contribution Non implant related
P.F.C. COCR	2007–2017	75,000	16,860	300	92,160	81.38%	18.61%
	2017–2019	52,800	29,320	500	82,620	63.90%	36.09%
	2019–2019 oct	58,000	29,760	500	88,260	65.71%	34.28%
ATTUNE	2007–2017	1,70,000	16,860	300	1,87,160	90.83%	9.16%
	2017–2019	55,000	29,320	500	84,820	64.84%	35.15%
	2019–2019 oct	64,000	29,760	500	94,260	67.89%	32.10%
ALL POLY	2007–2017	58,000	16,860	300	75,160	77.16%	22.83%
	2017–2019	39,000	29,320	500	68,820	56.66%	43.33%
	2019–2019 oct	45,000	29,760	500	75,260	59.79%	40.20%
AVERAGE	2007–2017	1,01,000	16,860	300	1,18,160	78.13%	21.86%
	2017–2019	48,933	29,320	500	78,753	62.13%	37.87%
	2019–2019 oct	55,667	29,760	500	85,927	65.16%	34.83%

COCR Cobalt–Chromium, *INR.* Indian rupee

Table 6 Cost audit of 'Direct patient expenditure' for TKA surgery in a private hospital

Private Hospital		Implant cost (INR.)	Package cost (INR.)	Other expenses (INR.)	Total cost (INR.)	% contribution by Implant	% Contribution Non implant related
PFC COCR	2007–2017	82,000	1,30,000	8000	2,20,000	37.27%	62.73%
	2017–2019	52,800	1,54,000	8000	2,14,800	24.58%	75.42%
	2019–2019 oct	58,000	1,54,000	8000	2,20,000	26.36%	73.64%
ATTUNE	2007–2017	2,10,000	1,30,000	8000	3,48,000	60.34%	39.66%
	2017–2019	55,000	1,54,000	8000	2,17,000	25.34%	74.66%
	2019–2019 oct	64,000	1,54,000	8000	2,26,000	28.31%	71.69%
ALL POLY	2007–2017	65,000	1,30,000	8000	2,03,000	32.01%	67.99%
	2017–2019	39,000	1,54,000	8000	2,01,000	19.40%	80.60%
	2019–2019 oct	45,000	1,54,000	8000	2,07,000	21.73%	78.27%
AVERAGE	2007–2017	1,19,000	130,000	8000	2,57,000	46.30%	53.70%
	2017–2019	48,933	1,54,000	8000	2,10,933	23.2%	76.80%
	2019–2019 oct	55,667	1,54,000	8000	2,17,667	25.57%	74.42%

COCR Cobalt–Chromium, *INR.* Indian rupee

in the private sector, as it has a major impact on the surgeon fees, consumables and other expenses.

Pradhan Mantri Jan Arogya Yojna (PM-JAY), launched in India as a component of the Ayushman Bharat scheme, is a fully funded and cashless provision covering almost 1,393 procedures including total knee replacement. TKA is provided under a package cost of INR. 80,000 under PM-JAY [22]. According to our study, an uncomplicated primary TKA with standardized implants in a government hospital, fits with difficulty under the cost umbrella provided by PM-JAY. Performing a TKA surgery in the private setup under the PM-JAY scheme, where the surgeon, hospital and consumable costs are not covered, would prove economically unviable and could persuade the private sector to offset the losses by using compromised protocols and sub-standard cheaper implants. An effective modification in the PM-JAY TKA package rates could thus ensure the use of standardized implants even in private sector ensuring better long term results.

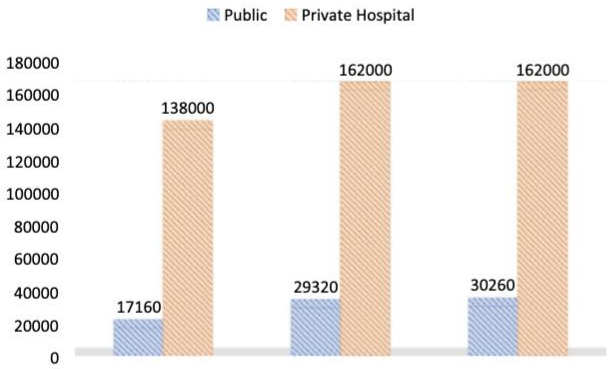

Fig. 3 Comparison of the non-implant related costs

There are a few limitations to the study. All the patients were operated by the same surgeon, using same implants, instruments and preventive care protocols. These variables are important determinants of the surgical results. The indirect costs like transportation, medications, productivity losses, that form an important component of the cost, were not taken into account in the cost analysis. Exclusion of bilateral simultaneous TKA but including staged bilateral TKA is likely to have an impact on cost comparative analysis, thus being a weakness of this study. The mean maximum follow-up of the patients in this study was 3 years 4 months and 3 years 2 months respectively. Longer follow-up period would be beneficial in detecting late prosthetic joint infections and implant survival rates. Inability to produce Kaplan–Meier survival plots due to shorter follow-up is one of the limitations of this study.

However, matching of the confounding factors, high number of cases, almost 1:1 matching of the cases and replication of the surgical protocols and surgeries being performed by the same surgeon in the two different operative setups was the major strengths of this study. Multi-center prospective matched studies using specific clinical care pathways undertaken by multiple surgeons are needed to further validate the reproducibility of these results.

The authors agree that the fact that the private hospitals score better in terms of housekeeping, sanitation, cleanliness, attract a large proportion of patients. However, the patient's willingness to pay for this higher than 'standard of care' does account for the increased surgical cost in the

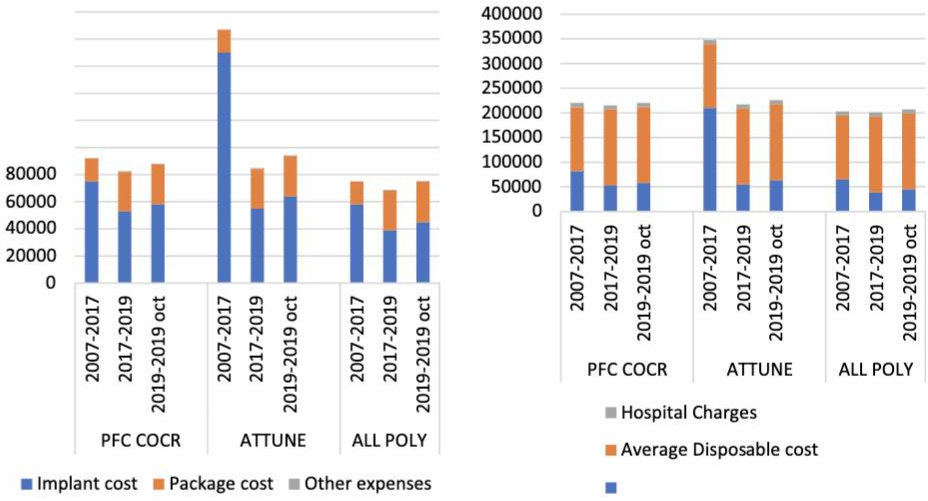

Fig. 4 **a** Trends and Breakdown of the total cost of surgery in the Government funded teaching hospital. **b** Trends and Breakdown of the total cost of surgery in the Private hospital setup

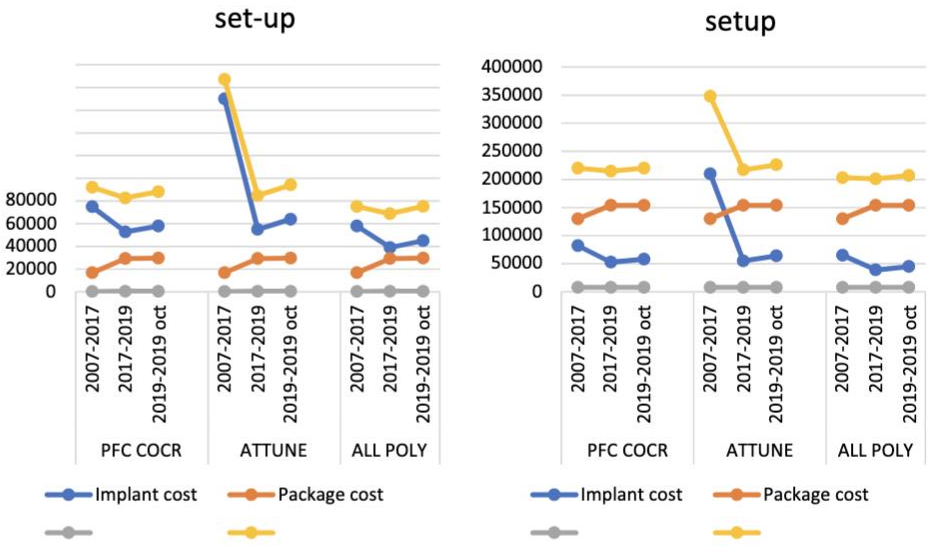

Fig. 5 **a** Timeline to depict change in the cost over the years in the Government funded teaching hospital. **b** Timeline to depict change in the cost over the years in the private hospital setup

private hospital setting. Deficient infrastructure, manpower, disproportionately high patient load are few of the challenges still being faced by the public hospitals in India [23].

Conclusions

It is possible to produce comparable outcomes and complication rates for TKA in government aided public hospitals compared to the private hospital and the same is possible at a significantly lesser 'Direct patient expenditure' of INR. 85,927. The cost of surgery and management of complications is far less in the public hospitals as compared to the private.

Author contributions All authors contributed to the study conception and design. Conceptualisation done by Shrinand V. Vaidya. Material preparation, data collection and analysis were performed by Keyur B. Desai, Amol S. Chavan and Dishit Vaghasia, Chintan S. Vaidya. The first draft of the manuscript was written by Keyur B. Desai and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. Final draft was edited and prepared by Keyur B. Desai under supervision of Shrinand V. Vaidya.

Compliance with Ethical Standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical standard This article does not contain any studies with human or animal subjects performed by the any of the authors.

Informed consent For this type of study informed consent is not required.

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