Research Article

Total Knee Arthroplasty, All-in-One versus Four-in-One Femoral Cutting Jig System: A Comparison Study

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Background. Total knee arthroplasty (TKA) is often indicated for end-stage knee osteoarthritis management. The posterior-stabilized (PS) implant is one of the TKA implants with various component designs, including femoral component cutting jigs. However, little is known about how the differences in cutting jig designs affect the outcomes. This study aims to compare the radiographic and functional outcomes of the patients who underwent cemented TKA using all-in-one and four-in-one femoral component PS implants.

Methods. A retrospective comparative study assessed patients who underwent cemented TKA using PS implants from 2018 to 2019. The patients were divided into all-in-one and four-in-one groups. Demographic data, surgery duration, postoperative radiological findings after one week, and functional outcomes after two years were collected and compared.

Results. A total of 96 patients were included in the study, 55 patients were in the all-in-one sample, and 41 patients were in the four-in-one sample. The majority of the patients in both groups were female, aged >60 years old, overweight (BMI ≥ 25), and presented with an ASA score of II. We found significantly shorter surgery duration in the all-in-one group compared to the four-in-one group (128.00 ± 36.24 vs. 210.61 ± 57.54, p = 0.000). The four-in-one group and the all-in-one group showed insignificant differences in α, β, δ, and γ angles (p = 0.476, 0.273, 0.594, and 0.818). The functional outcomes (SF-12, KSS, and KOOS) showed insignificant differences. Conclusion. There is no differentiation for the postsurgery functional and radiological outcomes between all-in-one and four-in-one implants.

1. Introduction

Knee osteoarthritis (OA) causes gradual functional impairment, stiffness, and pain. It is approximated that over a tenth of people aged 50 years or older are affected globally. In end-stage OA conditions or when all other surgical options fail, total knee arthroplasty (TKA) is indicated as the final option for knee OA management. Moreover, TKA is projected to increase due to the increased aging population in the future. During 2012–2019, there were 1,122,043 TKA procedures performed in the USA; by 2030, it was estimated there would be 1,921,000 TKA procedures performed annually [1]. Despite being considered a highly cost-effective surgery, the literature showed that up to 20% of the patients reported unsatisfactory outcomes [2]. Furthermore, there is little literature on which type of implant provides the best outcomes with the fewest complications.

The surgical technique chosen complied with the globally standardized surgical technique for cemented TKA today, namely, the measured resection, gap balancing, and hybrid technique [3]. In general, there are two types of TKA implants, namely the posterior-stabilized (PS) and cruciate-...
retaining (CR) systems. The surgeons do not retain both the anterior cruciate ligament (ACL) and the posterior cruciate ligament (PCL) in the PS system. In contrast, the surgeons maintain the PCL in the CR system but not the ACL. Although the continuing debate about the efficacy and superiority of the two systems, a meta-analysis study in 2016 concludes that there is no significant difference between their Knee Society Knee Score (KSS), pain score (KSPS), Hospital for Special Surgery score (HSS), kinematic characteristics (postoperative component alignment, posterior tibial slope, and joint-line) and postoperative complication rate. PS system seems to result in a better range of motion (ROM), but still not concluded if that made clinical advantages for postoperative patients [4]. However, the PS implants themselves come with various variations/designs; for instance, the femoral component consists of two designs: the all-in-one (universal) and four-in-one femoral cutting jigs. The all-in-one design only requires one instrument to perform the femoral bone resection, whereas the four-in-one design needs two instruments. The choice of implants from different companies will also determine the instrumentation kit, which may have implications for the operative steps and possibly clinical effectiveness. Thus, our study aims to compare the radiographic ($\alpha$, $\beta$, $\delta$, and $\gamma$ angle) also functional outcomes of the patients who underwent cemented TKA using all-in-one and four-in-one femoral component PS implants. For radiographic angle, the normal value of $\alpha$ and $\beta$ angle is $90 \pm 3^\circ$, $87 \pm 3^\circ$ for $\delta$ angle, and $3 \pm 3^\circ$ for $\gamma$ angle [5].

2. Material and Method

2.1. Study Design and Eligibility Criteria. This research is an analytic retrospective study of 96 patients, conducted in Dr. Soetomo General Hospital (41 patients) and Orthopedic Private Hospital (55 patients) in Surabaya, Indonesia. We collected the data of adults suffering from knee osteoarthritis who underwent cemented TKA using the posterior-stabilized system by several Orthopedic Surgeons from General Hospital and Orthopedic Private Hospital at Surabaya between 2018 and 2019. Our inclusion criteria were: (1) adults diagnosed with knee osteoarthritis Kellgren Lawrence grade 3–4, (2) underwent cemented TKA using either all-in-one (Medacta, Switzerland) or four-in-one (Johnson and Johnson, USA), all by posterior-stabilized implant system, and (3) have a minimum of two years of follow-up. We excluded patients with incomplete medical records, those who died within the observation period (two years after surgery), and those who refused to be included in the study. The preoperative score including SF-12, Short Form KSS, and Knee Injury and Osteoarthritis Outcome Score (KOOS) scores, were analyzed for differences and homogeneity in all scoring systems between the preoperative sample of two groups, patient-reported outcome measures (PROMs) evaluated by radiological outcome ($\alpha$, $\beta$, $\delta$, and $\gamma$ angle) and functional outcome (SF-12, Short Form KSS, and KOOS scores).

SF-12 consists of 12 questions to evaluate how patients feel and how well they can do their usual activities. The questionnaire evaluates general patient health, does the patient health give the limitation for moderate activities in daily life, is there any problem for regular activities as a result of the patient physical health, is there any problem for regular activities as a result of the patient’s emotional problem, is there any pain symptom that interferes housework and works outside the home, evaluates patient feel and how things have been for some period, and is there any interfere for social activities because of physical health and emotional problem. There will be a numeric score result from SF-12, physical and mental scores. Short-form KSS consist of 6 question to evaluate patient functional outcome: (1) for how long patient can walk before stopping due to knee discomfort, (2–5) how much does the patient knee bother during each activity, such as walking on an uneven surface, climbing or descending stairs, getting up from the low couch or chair without arms, and running activities, and (6) how much does patient knee bother during one discretionary activity. KOOS consists of 5 items to evaluate: pain (evaluate by nine questions to the patient), symptom (evaluate by seven questions to the patient), activities of daily living (evaluate by 17 questions to the patient), sport and recreation function (evaluate by five questions to the patient) and knee-related quality of life (evaluate by four questions to the patient).

2.2. Surgical Technique and Approach. The surgical technique performed in both groups was hybrid (combination of measured resection and gap balancing). However, the differences in surgery procedure between the two groups lay in distal femoral bone resection. The all-in-one (universal) group used only one jig to make five cuts (distal femur condyle, anterior cortical bone, posterior condyle, anterior and posterior diagonal) at the distal femur. In contrast, the four-in-one group utilized two cutting jigs: one jig to make four cuts (anterior cortical bone, posterior condyle, anterior and posterior diagonal), and another jig to make the last cut (distal femoral condyle). The surgical approach of these two samples was the medial parapatellar approach.

2.3. Data Collection and Assessment. The demographic data (sex, age, and body mass index (BMI)), preoperative ASA (American Society of Anesthesiology) score, surgery duration, postoperative radiological findings, and functional outcomes were recorded. Postoperative radiological findings were evaluated within one week, while the functional outcomes were assessed two years after surgery. The preoperative score (SF-12, Short Form KSS, and KOOS scores) of the two groups were compared by SPSS to ensure that the samples were homogenous.

The $\alpha$, $\beta$, $\delta$, and $\gamma$ angles of anteroposterior (AP) and lateral views of the knee radiographs in a standing position were measured (Figure 1) [6]: Alpha ($\alpha$) angle is the medial angle between the femoral anatomical axis and a line crossing the domes of the femoral component condyles on the AP radiograph (Figure 1(a)), with a normal range of $90 \pm 3^\circ$. Beta ($\beta$) angle is the medial angle between the tibial anatomical axis and a line drawn aligned to the tibial
component on the AP radiograph (Figure 1(b)), with a
normal range of $90 \pm 3^\circ$. Delta ($\delta$) angle is the posterior angle
between the tibial anatomical axis and a line drawn aligned
to the tibial component on the lateral radiograph
(Figure 1(c)), with a normal range of $87 \pm 3^\circ$. Gamma ($\gamma$)
angle is the proximal angle between the femoral anatomical
axis and a line drawn perpendicular to the femoral com-
ponent’s distal cement interface on the lateral radiograph
(Figure 1(d)), with a normal range of $3 \pm 3^\circ$.

The functional outcomes were evaluated using several
PROMs: SF-12 [7], Short Form KSS [8], and KOOS [9], with
higher scores indicating better outcomes. However, we could
not evaluate the instability and joint motion of KSS because
of the coronavirus pandemic; thus, we used the KSS short
form [10].

2.4. Data Analysis. The demographics and postoperative
outcomes of the two groups were compared and analyzed;
we also compared preoperative scoring (SF-12, Short Form
KSS, and KOOS) between the two groups to ensure that
preoperative data between the two samples was used ho-
mogenous. Discrete data were presented in frequency and
percentage (%), while continuous data were presented in
mean and standard deviation (mean $\pm$ SD). Discrete data
were analyzed using Chi-square or Fisher’s test. A normality
test for continuous data was performed using the Shaprio-
Wilk test. Normally distributed data were analyzed using the
independent $t$-test, whereas the abnormally distributed data
were analyzed using the Mann-Whitney test. A value of
$p < 0.05$ was considered significant. The statistical analyses
were performed using SPSS 25.0 (SPSS Inc., Chicago, USA).

3. Results

96 patients met the inclusion criteria. The demographic of
included patients is presented in Table 1. Overall, the ma-
jority of the patients in both groups were female, aged >60
years old, overweight (BMI $\geq 25$), and presented with an
ASA score of II (with mild systemic disease). After we do
statistical analysis, there are no significant demographic
profile differences. There is homogeneity from all variances
between the two groups (except for the ASA score, and this
statistical significance and heterogeneity clinical significance
is debatable), which means the samples were homogenous.

The preoperative score comparison (SF-12, Short Form
KSS, and KOOS scores) of the two groups is presented in
Table 2. We found insignificant differences and homogeneity
in all scoring systems between preoperative samples of the
two groups. KOOS pain, KOOS quality of life, and KSS
running evaluation from two samples have the same score,
so there is no value for homogeneity of variances from that
variables.

The outcome comparison (surgery duration, radio-
graphic (X-ray)) finding and functional outcomes (SF-12,
Short Form KSS, and KOOS scores) of the two groups are
presented in Table 3. We found significantly shorter surgery
duration in the all-in-one (universal) group than in the four-
in-one group ($p = 0.000$), the other outcome comparisons
showed insignificant differences.

4. Discussion

The demographics of our patients, who were dominated by
overweight females aged >60 years old, were similar across
the two groups (Table 1). Previous studies have also reported
that TKA is common in females [11, 12] due to the increased
risk of osteoarthritis. Female is prone to osteoarthritis be-
cause, in advanced age (postmenopausal), the chon-
droprotective effect of estrogen diminishes as the estrogen
level decreases. Increased weight has also been linked to OA
due to adipose tissue’s increased adipokines (adiponectin
and leptin) and proinflammatory cytokines (TNF-$\alpha$, IL-1,
and IL-6) production. These adipokines and proin-
flammatory cytokines induce and enhance the production of
matrix metalloproteinases (MMPs) and prostaglandins
while inhibiting proteoglycans and collagen type II syn-
theses. Hence, they are crucial to cartilage matrix degra-
dation in OA pathogenesis [13].

Our study population characteristics showed a significant
difference in the ASA score, which is widely used to determine
patients’ physical status and help to predict operative risks.
Although previous studies have revealed that higher ASA
scores were associated with more complications and mortalities
in general [14], a study by Hooper et al. reported that the
mortality rates and functional outcomes (Oxford scores)
Table 1: Demographics of the patients.

| Parameter              | All-in-one (n = 55) | Four-in-one (n = 41) | p value | Homogeneity Method |
|------------------------|---------------------|----------------------|---------|--------------------|
| Sex                    | Male: 12 (22.5%)    | Male: 10 (10.4%)     | 0.767   | 0.561** Chi-square test |
|                        | Female: 43 (77.5%)  | Female: 31 (89.6%)   |         |                    |
| Age (years)            | 65.69 ± 8.01        | 62.83 ± 7.96         | 0.086   | 0.583** Independent t-test |
| BMI (kg/m²)            | 27.80 ± 4.66        | 28.00 ± 3.46         | 0.676   | 0.246** Mann-Whitney test |
| ASA score              | ASA I: 7 (7.3%)     | ASA I: 12 (12.5%)    | 0.044*  | 0.000 Chi-square test |
|                        | ASA II: 48 (50%)    | ASA II: 29 (30.2%)   |         |                    |

Note. *Statistically significant (p < 0.05). **Statistically homogenous (p ≥ 0.05).

Table 2: Preoperative score comparison between all-in-one and four-in-one implant.

| Parameter                          | All-in-one (n = 55) | Four-in-one (n = 41) | p value | Homogeneity of variances |
|------------------------------------|---------------------|----------------------|---------|--------------------------|
| SF-12                              |                     |                      |         |                          |
| Physical score                     | 20.54 ± 0.64        | 20.53 ± 0.65         | 0.609   | 0.719**                  |
| Mental score                       | 61.49 ± 2.45        | 60.96 ± 2.26         | 0.254   | 0.722**                  |
| How long can you walk (0–20)       | 9.82 ± 2.01         | 10.05 ± 2.01         | 0.578   | 0.602**                  |
| Walking on an uneven surface (0–15) | 7.64 ± 1.65        | 7.46 ± 1.51          | 0.578   | 0.602**                  |
| Climbing or descending stairs (0–15) | 7.36 ± 1.65        | 7.54 ± 1.52          | 0.578   | 0.602**                  |
| KSS (short form)                   |                     |                      |         |                          |
| Getting up from a low couch or chair without arms (0–15) | 7.64 ± 1.65 | 7.46 ± 1.51 | 0.578 | 0.602** |
| Running (0–20)                     | 8.00 ± 0.00         | 8.00 ± 0.00          | 1.000   |                          |
| Discretionary activity (0–15)      | 7.36 ± 1.50         | 7.54 ± 1.51          | 0.578   | 0.602**                  |
| Total (0–100)                      | 47.81 ± 2.01        | 48.05 ± 2.02         | 0.578   | 0.602**                  |
| Pain                               | 56.00 ± 0.00        | 56.00 ± 0.00         | 1.000   |                          |
| Symptoms                           | 48.18 ± 2.01        | 47.95 ± 2.04         | 0.578   | 0.602**                  |
| KOOS                               |                     |                      |         |                          |
| Activities of daily living (ADL)   | 56.45 ± 0.50        | 56.51 ± 0.50         | 0.578   | 0.602**                  |
| Sport and recreation               | 47.73 ± 2.51        | 47.44 ± 2.53         | 0.578   | 0.602**                  |
| Quality of life                    | 44.00 ± 0.00        | 44.00 ± 0.00         | 1.000   |                          |

Note. All tests were analyzed using Mann-Whitney tests. *Statistically significant (p < 0.05). **Statistically homogenous (p ≥ 0.05).

Table 3: Outcome comparison between all-in-one & four-in-one implant.

| Parameter                          | All-in-one (n = 55) | Four-in-one (n = 41) | p-value |
|------------------------------------|---------------------|----------------------|---------|
| Surgery duration (minutes)         | 128.00 ± 36.24      | 210.61 ± 57.54       | 0.000*  |
| X-ray finding                      | Alpha (α) angle1    | 97.02 ± 2.77         | 96.35 ± 5.46 | 0.476 |
|                                   | Beta (β) angle1     | 86.62 ± 2.80         | 86.03 ± 2.41 | 0.273 |
|                                   | Delta (δ) angle1    | 86.33 ± 4.76         | 86.81 ± 4.92 | 0.594 |
|                                   | Gamma (γ) angle     | 7.51 ± 5.47          | 7.38 ± 4.56 | 0.818 |
| SF-12                              | Physical score      | 51.79 ± 7.99         | 51.58 ± 7.96 | 0.119 |
|                                   | Mental score        | 58.10 ± 7.22         | 58.06 ± 5.76 | 0.815 |
|                                   | How long can you walk (0–20) | 17.82 ± 2.96 | 16.85 ± 2.76 | 0.059 |
|                                   | Climbing or descending stairs (0–15) | 14.78 ± 0.96 | 15.00 ± 0.00 | 0.131 |
| KSS (short form)                   | Getting up from a low couch or chair without arms (0–15) | 14.56 ± 2.12 | 14.49 ± 2.41 | 0.724 |
|                                   | Running (0–20)      | 1.04 ± 2.96          | 1.61 ± 4.09 | 0.676 |
|                                   | Discretionary activity (0–15) | 14.56 ± 2.12 | 15.00 ± 0.00 | 0.079 |
|                                   | Total (0–100)       | 76.67 ± 7.98         | 74.90 ± 8.07 | 0.063 |
|                                   | Pain                | 97.20 ± 5.05         | 98.98 ± 1.59 | 0.082 |
|                                   | Symptoms            | 79.07 ± 8.63         | 80.76 ± 5.33 | 0.184 |
| KOOS                               | Activities of daily living (ADL) | 97.31 ± 5.51 | 98.34 ± 1.76 | 0.494 |
|                                   | Sport and recreation| 69.87 ± 16.83        | 72.80 ± 8.37 | 0.736 |
|                                   | Quality of life     | 88.87 ± 12.26        | 92.93 ± 3.16 | 0.178 |

Note. All tests were analyzed using Mann-Whitney tests unless stated otherwise. 1, analyzed using an independent t-test. *Statistically significant (p < 0.05).

Following TKA in ASA I (completely fit) and II (with mild systemic disease) patients were similar (p > 0.05) [15]. As all the included patients were in the range of ASA I-II, the clinical relevance of the statistical difference found is therefore neglectable; thus, our study samples are homogenous and not biased.

TKA procedures always increase every year, making implant companies innovate to simplify the design, make operating procedures easier, and improve cutting accuracy. The all-in-one femoral cutting had created to simplify the surgical procedure and minimize human error during the surgery. This design was also created to reduce surgery...
duration because the surgeon only needs one jig to make a femoral cut. Based on the previous study by Yasin et al. [16], the result using that implant was satisfactory, but we need to follow up for radiological and functional outcomes.

Our outcome comparison showed a significantly shorter surgery duration in the all-in-one (universal) group compared to the four-in-one group (128.00 ± 36.24 vs. 210.61 ± 57.54 minutes, respectively, \( p = 0.000 \)). Several factors for longer surgery duration are grouped into three categories: patient, surgeon, and surgical factors. The patient factors associated with prolonged operative time include advanced patient age, male patients, ASA 3+ (higher degree of comorbidities), obesity, preoperative laboratory findings, and more complex cases [17, 18]. Surgeon factors include surgeon experience (level of training) [17, 19]. Surgical factors such as anesthesia type intraoperative transfusion requirement should also be considered [17, 19]. In this study, we suggest another factor, namely the difference in femoral cutting jigs design (all-in-one/universal vs. four-in-one), as another factor contributing to the surgery duration. The all-in-one femoral cutting jig requires only one instrument for five bone resections at the distal femur. In contrast, the four-in-one needs two instruments that entail additional time to be secured in position.

Previous studies have reported that longer surgery duration was associated with complications, leading to higher revision rates [18, 19]. Interestingly, extensive studies involving national joint registries from New Zealand and the USA showed that not only long TKA surgery duration (>120 minutes and >150 minutes, respectively) was associated with higher revision rates but also the very short ones (<40 minutes and <90 minutes, respectively). While longer procedures lead to more infection and wound dehiscence risks, the very short ones cause more aseptic loosening, which is as detrimental as the former's [20]. Our average operative time was relatively longer than the studies mentioned earlier; this phenomenon seems to be a common finding in developing countries [21], presumably due to the lower TKA volume in developing countries. Improving operating volume from <10 procedures/hospital/year to >200 procedures/hospital/year was associated with an average of 25 minutes shorter operating time in cemented joint replacement surgeries [22].

Nevertheless, literature has reported that the operating time was irrelevant to patients’ functional outcomes (assessed by the Oxford score) at six months, five years, and ten years follow-up after TKA surgery [19]. Likewise, our findings showed that the functional outcomes’ differences of both groups are insignificant (\( p > 0.05 \)), regardless of the significant surgery duration difference attributable to different femoral component cutting jigs. These insignificant functional outcome findings are expected because the two groups utilized the same prosthesis system, i.e., the PS TKA system. The only difference between the two groups is the femoral cutting jigs. Very few studies compared the different instrument designs in the PS TKA system. Indelli et al. compared different cutting jigs amongst three popular PS knee prostheses (Sigma PS-Johnson and Johnson, Persona-Zimmer, and Vanguard-Biomet). They investigated the maximum volumetric bone resection required for the three different cutting jig designs and found significant differences in the tridimensional PS housing area of the three designs that would result in extra bone resection in certain cutting jig designs [23]. However, to our knowledge, there is no study comparing the effects of femoral cutting jig design differences on the outcomes.

Our study has several limitations. Firstly, we could not evaluate the instability and joint motion as a part of KSS because of the coronavirus pandemic. However, the KSS instrument used was the KSS short form, which has also been validated [10]. Secondly, there might be a performance bias for surgery duration time because the patients were operated on by different surgeons. Because of the limitation of the patient sample, we cannot control these confounding factors, and we do not have a huge number of patients post-TKA that operated on by the same surgeon. Future studies should compare the postoperative ROM joint stability with a larger sample and evaluate postoperative readmissions, reoperations also infections rate.

5. Conclusion

There is no differentiation for the postsurgery functional and radiological outcome between all-in-one and four-in-one TKA cutting jig system.

Data Availability

The data used to support the findings of this study are included in the article.

Ethical Approval

This study has been reviewed and received ethical clearance from the Hospital Institutional Review Board (No. 215/EC/KEPK/FKUA/2020).

Disclosure

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflicts of Interest

The authors declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

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