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No difference in 13-year survival after medial pivot or central pivot mobile bearing total knee arthroplasty. A propensity matched comparative analysis

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Abstract

Purpose The present study was designed to evaluate the long-term results (more than 10 years) of mobile bearing total knee arthroplasty (TKA) and to compare the survival of medial pivot axis (MPA) and central pivot axis (CPA) TKAs. The primary hypothesis was that the 10- to 15-year survival rate of MPA TKAs will be better than CPA TKAs.

Methods A national, multicenter, retrospective study was performed in France. In this case–control design, 1154 TKAs were paired into the CPA group (control group: 577 cases) and MPA group (study group: 577 cases) based on a logistic regression analysis of age, gender, body mass index and severity of the coronal deformity, defining the propensity score for each case. Final survival information follow-up was obtained for 946 cases (82%).

Results There was no significant difference between the control and study groups for any baseline data. Twenty-two prosthetic revisions (2%) were performed for mechanical reasons during the follow-up period. There was no significant difference between the 13-year survival rates of CPA (98%) and MPA (97%) TKAs. There was no significant difference between groups in their final Oxford and Knee Society scores.

Conclusion Our findings do not support the assumption that medialization of the pivot axis of a mobile bearing TKA improves clinical results or survival.

Level of evidence Level III.

Keywords Knee · Total knee arthroplasty · Total knee replacement · Mobile bearing · Survival · Central pivot · Medial pivot

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Introduction

It has been shown that a normal knee has a different mechanical pattern on the medial side (more stable) than on the lateral side (more mobile), resulting in medialization of the knee's rotational axis [10, 13]. Medialization of the pivoting center of a TKA is supposed to facilitate or even induce more physiological kinematics [29]. Experimental studies report encouraging results [4, 17, 23, 32, 33]. Consequently, it has been postulated that TKAs with a more physiological medial pivoting axis (MPA) may yield better outcomes than conventional TKAs with a central pivoting axis (CPA) [5]. However, the results of comparative studies already published are not unanimous [2, 24, 25, 27, 30], and no long term comparative study with more than 10-year follow-up has yet been published.

The present study was designed to evaluate the long-term results (more than 10 years) of mobile bearing TKAs and to compare the survival of MPA and CPA TKAs. The primary hypothesis was that the 10- to 15-year survival rate of MPA TKAs will be better than CPA TKAs.

Methods

A retrospective study was performed in eight French university hospitals and private hospitals with high knee surgery volumes.

All patients who underwent TKA implantation (regardless of the system used) between January 2001 and December 2004 in the participating hospitals were included consecutively, without exclusion criteria. The usual demographic data were collected. The initial Knee Society Score was calculated [16]. The initial coronal deformity was measured on long leg anteroposterior radiographs as the angle between the mechanical axis of the femur and tibia with a validated technique involving an accuracy of ± 1.3 degree [34]. Angles ≤ 176° were considered as varus knees, angles ≥ 184° were considered as valgus knees, the remaining knees were considered as normal knees.

All participating surgeons aimed for a coronal angle correction of ± 3° from the neutral axis and an acceptable ligament balance with standard, visual evaluation. All centers implanted a mobile bearing TKA; two centers implanted MPA TKAs only, while six centers implanted CPA TKAs only.

The postoperative coronal deformity was measured using the same technique as before implantation. All patients were contacted after 10 or more years to determine the survival of the TKA. The need for revision, the date and reasons were noted. Oxford [9] and Knee Society scores were collected. Patients who could not attend the review visit in person were interviewed by telephone. For patients lost to follow-up, the family or general practitioner was contacted to obtain information about the TKA's survival.

The study was conducted according to the Declaration of Helsinki and its last amendments. The local ethics committee at Strasbourg University approved the study, which was registered on clinicaltrials.gov (NCT02651571).

Statistical analysis

Patients were separated into two groups based on the TKA design: MPA or CPA. Patients were paired in the two groups based on logistic regression analysis of age (with 5-year intervals), gender, body mass index (with 5 kg/m^2 intervals), index coronal deformity (varus, valgus or normal knee), defining the propensity score for each case.

The primary endpoint was the occurrence of a revision for any mechanical reason. The secondary endpoints were the Oxford and Knee Society scores at the latest available follow-up. Survival curves were calculated using the actuarial technique. The influence of TKA design was analyzed by a log rank test at a 5% level of significance. Oxford and Knee Society scores were compared between groups with Student's *t* test at a 5% level of significance.

The sample size was calculated with following hypotheses: 10-year survival rate of the control group = 85%, 10-year survival rate of the study group = 93%, alpha risk = 0.05, beta risk = 0.20, giving a minimal number of cases of 478. Missing data were extrapolated by iterative (20 times) imputation.

Results

During the study period, 1604 TKAs were implanted. Preoperative data are reported in Table 1.

Various TKA systems were used: one MPA TKA system (E-motion®, Aesculap, Tuttlingen, FRG [19]) in 578 cases, all cemented, and five CPA TKA systems: ROCC® (Biomet, Warsaw, USA [3]) in 391 cases (222 cemented, 169 cementless), Score® (Amplitude, Valence, France [7]) in 306 cases (107 cemented, 134 cementless, 65 hybrid), Profix® (Smith and Nephew, London, UK [35]) in 246 cases (18 cemented, 80 cementless, 148 hybrid), First® (Symbios, Yverdon-les-Bains, Switzerland [12]) in 51 cases (all cemented), and NexGen® (Zimmer, Warsaw, USA [31]) in 32 cases (all cemented).

All MPA TKAs were implanted with a non-image-based navigation system (OrthoPilot®, Aesculap, Tuttlingen, FRG [18]). Sixty CPA TKAs (Score system) were

Table 1 Baseline data—all patients

Age: mean (SD)	69.6 years (7.7 years)
Gender ratio (male/female)	34%/66%
Body mass index: mean (SD)	29.6 kg/m^2 (4.5 kg/m^2)
Knee society score—clinical (maximum = 100 points): mean (SD)	38 (16)
Knee society score—functional (maximum = 100 points): mean (SD)	47 (18)
Knee society score—total (maximum = 200 points): mean (SD)	85 (27)
Varus knees: number (percentage)—mean coronal angle (SD)	962 (60%) 171° (4°)
Valgus knees: number (percentage)—mean coronal angle (SD)	330 (20%) 189° (4°)
Normal knees: number (percentage)—mean coronal angle (SD)	312 (20%) 180° (2°)

Table 2 Baseline data—paired cases

	CPA TKA	MPA TKA	Significance
Age: mean (SD)	69.2 years (7.5 years)	70.1 years (7.2 years)	$p = 0.04$
Gender ratio (male/female)	0.64	0.59	$p = 0.08$
Body mass index: mean (SD)	28.9 kg/m^2 (4.4 kg/m^2)	28.9 kg/m^2 (5.1 kg/m^2)	
Knee society score—clinical (maximum = 100 points): mean (SD)	37 (15)	39 (16)	$p = 0.08$
Knee society score—functional (maximum = 100 points): mean (SD)	48 (18)	46 (17)	$p = 0.16$
Knee society score—total (maximum = 200 points): mean (SD)	85 (27)	86 (27)	$p = 0.85$
Varus knees: number (percentage)—mean coronal angle (SD)	289 (50%) 171° (4°)	289 (50%) 171° (4°)	$p = 1.00$ $p = 0.12$
Valgus knees: number (percentage)—mean coronal angle (SD)	136 (24%) 189° (4°)	136 (24%) 189° (4°)	$p = 1.00$ $p = 0.69$
Normal knees: number (percentage)—mean coronal angle (SD)	152 (26%) 180° (2°)	152 (26%) 180° (2°)	$p = 1.00$ $p = 0.42$

implanted with a non-image-based navigation system (Amplivision®, Amplitude Valence, France [7]). The other TKAs were implanted with conventional mechanical instruments.

In the end, 1154 cases were paired into the CPA group (control group: 577 cases) and the MPA group (study group: 577 cases). There was no significant difference between control and study groups for any baseline data, except for age at implantation and for the TKA system used (Table 2).

The study flow-chart is provided as Fig. 1. Two hundred eight patients died prior to the review (18%) and were included as censored data at the time of death. Two hundred seventy-six patients were lost to follow-up (24%) and were included as censored data at the time of last available clinical examination. Final follow-up was obtained for 670 patients (58%).

Twenty-two prosthetic revisions were performed for mechanical reasons during the follow-up period (2%): 12 in the CPA group and 10 in the MPA group ($p = 0.67$) (Table 3). The overall survival rate after 14 years was 97%. There was no significant difference between the 13-year survival rates of CPA (98%) and MPA (97%) TKAs. There was no significant difference between the groups for the final Oxford and Knee Society scores in the 670 patients who were still alive and had not undergone revision surgery (343 in the CPA group and 327 in the MPA group, $p = 0.34$) (Table 4).

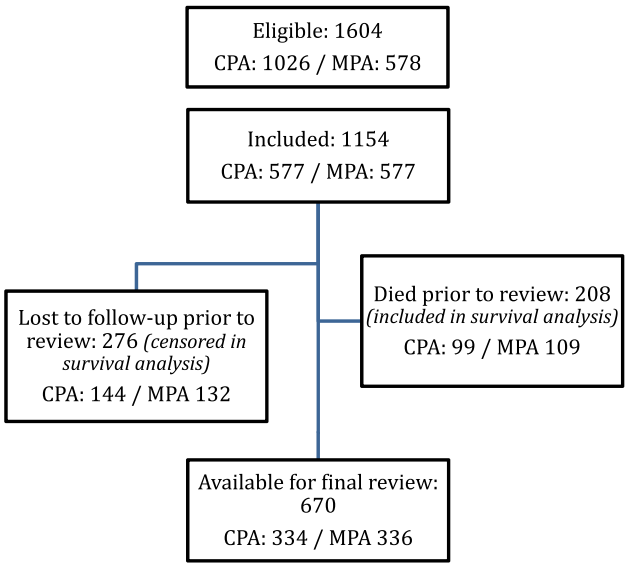

Fig. 1 Study flowchart

Discussion

The main finding of this study is that the location of the TKA's rotational axis did not impact the long-term survival.

Table 3 Revised cases (infection excluded)

Complication	Group	Navigation	Fixation	Time after TKA (years)	Revision performed
Instability	CPA	No	Cementless	1	Complete exchange
Instability	MPA	Yes	Cemented	1	Complete exchange
Pain	CPA	No	Cemented	1	Complete exchange
Loosening	CPA	No	Hybrid	2	Complete exchange
Stiffness	MPA	Yes	Cemented	2	Insert exchange
Loosening	MPA	Yes	Cemented	2	Complete exchange
Loosening	CPA	No	Cemented	2	Femur exchange
Instability	MPA	Yes	Cemented	3	Insert exchange
Pain	CPA	Yes	Cementless	4	Complete exchange
Loosening	CPA	No	Cemented	4	Complete exchange
Loosening	MPA	Yes	Cemented	4	Complete exchange
Anterior knee pain	CPA	No	Hybrid	4	Patella resurfacing
Loosening	CPA	Yes	Cemented	5	Tibia exchange
Periprosthetic fracture	CPA	No	Cementless	5	Complete exchange
Instability	MPA	Yes	Cemented	6	Insert exchange
Loosening	MPA	Yes	Cemented	7	Tibia exchange
Insert luxation	CPA	No	Cemented	8	Insert exchange
Loosening	CPA	No	Cementless	10	Complete exchange
Instability	MPA	Yes	Cemented	10	Complete exchange
Loosening	MPA	Yes	Cemented	10	Complete exchange
Loosening	CPA	No	Hybrid	11	Femur exchange
Insert wear	MPA	Yes	Cemented	13	Insert exchange

Table 4 Results—final oxford and knee society scores

	CPA TKA ($N=343$)	MPA TKA ($N=327$)	Significance
Oxford knee score (maximum = 60 points) (mean ± SD)	52 (9)	53 (8)	$p=0.22$
Knee society score—clinical (maximum = 100 points) (mean ± SD)	93 (11)	94 (12)	$p=0.17$
Knee society score—functional (maximum = 100 points) (mean ± SD)	77 (20)	76 (21)	$p=0.66$
Knee society score—total (maximum = 200 points) (mean ± SD)	170 (27)	170 (28)	$p=0.81$

The clinical results published in the literature about the respective results of MPA and CPA TKAs are controversial. Some cohort studies report satisfactory results after implantation of a MPA TKA [5, 15, 20, 28]. In vivo knee kinematics may be improved if a medial pivot is present [1]. More relevant, several comparative studies reported better clinical results or better survival after implanting a MPA TKA compared to conventional CPA TKAs [24, 27]. However, other authors did not observe any significant difference between MPA and CPA TKAs [2, 25]. Some papers even report worse results after MPA TKA implantation [30]. Registry studies are inconclusive [6, 26]. These disparate conclusions can be explained by the different knee systems being used more than by the kinematic design itself. Furthermore, the kinematic behavior specifically in rotation may be only marginally impacted by the implant design [2, 26, 36].

The results of our study do not support the assumption that medialization of the pivot point of a mobile bearing TKA routinely improves clinical results or survival. Our findings are consistent with other reports, but with a longer follow-up [36]. One might assume that the kinematic design of a TKA, and specifically the location of the pivot point, is not critical for good clinical results and long-term survival of a TKA. This factor may not be considered by surgeons when they decide which TKA system will be implanted.

Limitations

There are several limitations to this study. This is a retrospective study, with all the risks of bias inherent in this type of study. Age at implantation was different between groups, although the difference was less than 1 year, and

likely not clinically relevant. The fixation technique and the use of navigation differed between groups; however, these elements may have little impact on TKA survival [8, 11, 22, 27]. Furthermore, five different CPA designs were used in the control group, while only one MPA design was used in the study group. The propensity matching process can compensate for the biases related to known risk factors [21], while unknown risk factors remain uncontrolled. Actually, there was no significant difference between CPA and MPA groups in terms of the generally accepted prognostic factors for the long-term survival of TKAs. The accuracy of implantation might be inconsistent between hospitals and surgeons; however, all surgeries were performed by, or under the direct supervision of, a high-volume knee surgeon with extensive experience in the implant system and surgical technique. Survival was analyzed retrospectively, explaining the high percentage of patients lost to follow-up. However, this can also be attributed the patients being older during the procedure and the long time elapsed after the procedure. In fact, the percentage of patients lost to follow-up is consistent with other studies with similar follow-up time [14]. Furthermore, we confirmed that there was no significant difference in all preoperative data between these patients and those with available 10-year follow-up. Only a limited number of TKA systems were used, and the conclusion might be different when comparing other systems.

Conclusion

The results of this study do not support the assumption that medialization of the pivot axis of a mobile bearing TKA improves clinical results or survival.

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Author contributions JYJ designed the study, monitored data collection, performed data analysis, drafted the manuscript and wrote the final manuscript. DS designed the study, supervised data collection and analysis, reviewed the drafted manuscript and the final manuscript. All authors monitored data collection in their own center. All authors reviewed the drafted manuscript. All authors read and accepted the final manuscript.

Compliance with ethical standards

Conflict of interest JYJ receives royalties from AESCULAP, is a paid consultant for FH ORTHOPEDICS and GLOBUS MEDICAL, is a member of the board of the CAOS-International Society and of the International Society for Technology in Arthroplasty. TG receives royalties from AMPLITUDE. FC receives royalties from AMPLITUDE and DEDIENNE. DS receives royalties from AESCULAP.

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