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## Original article

# A RETROSPECTIVE COMPARISON OF CENTRAL AND POSTERIOR HINGE JOINTS IN 53 TOTAL KNEE ARTHROPLASTIES

Arthur **Justo**<sup>1</sup>, Hugo **Vilette**<sup>1</sup>, Matthieu **Ehlinger**<sup>2</sup>, Gilles **Pasquier**<sup>3</sup>, Pierre **Laumonerie**<sup>1</sup>, Etienne **Cavaignac**<sup>1</sup>

<sup>1</sup> Service de chirurgie orthopédique et traumatologique, Hôpital Pierre Paul Riquet, 1 place du Dr Baylac, 31059 Toulouse cedex, France

<sup>2</sup> Service de chirurgie du membre inférieur et de traumatologie, Haute pierre II, Hôpitaux Universitaires de Strasbourg, 1 Avenue Molière, 67098 Strasbourg cedex, France

<sup>3</sup> Service de chirurgie orthopédique et traumatologique, Hôpital Roger Salengro, CHU Lille, Avenue Émile Laine, 59037 Lille cedex, France

**Corresponding author:** Arthur Justo,

Service d'Orthopédie, Hôpital Pierre Paul Riquet, place du Dr Baylac, TSA 40 031, 31059 Toulouse cedex 9, France

Email: arthur.justo@hotmail.fr, Tel.: +33 (0)6 77 43 05 64

## Abstract

**Introduction:** The number of hinged total knee arthroplasty (HTKA) procedures is constantly increasing. There are two hinge types: central (CHTKA) and posterior (PHTKA). The primary purpose of the study was to compare implant survival in patients with CHTKA versus PHTKA.

The secondary purpose was to analyze the radiological and clinical results of the implants.

**Hypothesis:** There is no difference between the two groups.

**Materials and methods:** This study involved 53 patients who received a HTKA for either primary, trauma or revision surgery, of these 32 were in the CHTKA group and 21 in the PHTKA group, with a mean age of 69 years (38–89). The exclusion criteria were: etiology of sepsis, incomplete records and refusal to use data. The revision rate, with the replacement of prosthetic components, was the primary endpoint. The secondary outcomes were: mobility, complications, VAS, IKS, Devane, Charnley and Oxford knee scores, and radiological progression.

**Results:** The mean follow-up was 51 months (1–139). At 60 months, overall survival rate of the HTKA was 81%, with a confidence interval (CI) of 95% (71–93.2), and there was no difference between CHTKA and PHTKA, 77.7% (95% CI, 63.3–95.4) versus 85.7% (95% CI, 72–100),  $P = .625$ , respectively. Flexion was  $101^\circ \pm 15$  (80–140) for CHTKA versus  $98^\circ \pm 12$  (30–130) for PHTKA,  $P = .006$ . VAS was  $0.5 \pm 16$  (0–6) for CHTKA versus  $1.6 \pm 14$  (0–4) for PHTKA,  $P = .000008$ . The IKS was  $103 \pm 39$  (15–180) for CHTKA versus  $81 \pm 51$  (9–200) for PHTKA,  $P = .03$ . There were no differences in either radiological progression, complications or other functional scores.

**Discussion:** No significant difference was observed between the survival of CHTKA and PHTKA. CHTKA had better flexion, reduced VAS and increased IKS. Surgeons should be aware of these findings and apply careful consideration to their choice of hinge.

**Level of Evidence:** IV; retrospective single-center study.

**Keywords:** Total knee arthroplasty, hinge, central or posterior, survival.

## 1. Introduction

The number of total knee arthroplasty (TKA) procedures continues to increase [1]. In the USA, it is estimated that by 2030, the number of primary TKA surgeries will increase by 673% and revisions by 601% [2]. The trend is similar in France [3, 4]. The socioeconomic impact is considerable [1].

Orthopedic surgeons will be faced with situations that require the use of hinged implants [5]. The first-generation arthroplasties were comprised of a single fixed hinge [6], which helped overcome significant instabilities [7], and were used in tumor surgery [8]. Their associated one degree of freedom resulted in cases of loosening and patellofemoral instability [9]. The results of the second-generation rotating hinged implant [10] were poor [10, 11]. The third-generation modular arthroplasties [10, 12, 13] achieved better outcomes [14] and had wider applications for substantial bone defects, in particular metaphyseal bone loss [15], severe deformities and ligamentous laxities [16], distal femur fractures in elderly patients [17], and tumors [15–17].

Long et al reported that the offset variability induced a difference in the patellar ligament moment arm that favored TKA with a central hinge (CHTKA) over TKA with a posterior hinge (PHTKA) [13]. There are no clinical assessments comparing these two implants. It is conceivable that these biomechanical differences may have a significant clinical impact.

The primary hypothesis was that the survival of CHTKA and PHTKA were similar. Survival was assessed by the number of surgical revisions with a change of implant.

The secondary outcomes were complications and clinical, functional and radiological findings.

## **2. Materials and Methods**

### **2.1. Patients and study design**

This single-centered, retrospective, observational study was carried out at the Toulouse University Hospital using prospective data collected from January 1, 2006, to December 31, 2016.

Consent was obtained from the ethics board (RNIPH (*Recherche N'impliquant pas la personne humaine* [research not involving human subjects] May 2020).

The inclusion criteria were: age of 18 years and older, primary HTKA and revision. The exclusion criteria were etiologies and complications of sepsis and lack of radiological and clinical follow-up. All patients had undergone a radiological and clinical assessment during a consultation. The radiological assessment was performed with PACS (Picture Archiving and Communication System).

Fifty-three patients were included and divided into two groups (Figure 1): 32 patients for RHK-type of CHTKA (NexGen® Rotating Hinge Knee, Zimmer Biomet, Warsaw, USA) and 21 patients for MRH-type of PHTKA (Global Modular Replacement System® Modular Rotating Hinge, Stryker Corporation, Kalamazoo, USA) (Figure 2).

### **2.2 Endpoint and Outcomes.**

The primary endpoint was the analysis of implant survival obtained by the rate of surgical revisions to replace implant components.

The secondary outcomes assessed the incidence of complications, as well as the clinical, functional and radiological findings.

### **2.3 Assessment.**

The Charnley [18], Devane [19], IKS [20] and Oxford [21] functional scores were used. Postoperative complications were grouped into cicatricial disunity, dislocation, loosening, wear of bearing surfaces, patellofemoral abnormality, and periprosthetic fracture. The radiological analysis was based on AP, lateral, Schuss and sunrise views of the patella with a flexion of 30 degrees, and the entire lower limb in weight-bearing bipedal stance. It assessed

angles and patellar height, and looked for signs of loosening, in particular the presence of periprosthetic radiolucent lines. The Anderson Orthopedic Research Institute (AORI) classification [22] was used to assess loosening. The patellar height was evaluated using the Blackburne-Peel ratio [23]. Follow-up data were collected clinically and prospectively at 1 and 6 months, 1 year and then every 2 years.

## **2.4 Statistics.**

A descriptive analysis [mean, standard deviation (SD) and extreme values for continuous variables, and frequency and proportion for categorical data] was performed to summarize the reported variables. A Wilcoxon rank sum test (nonparametric test), and a Fisher's exact test (nonparametric test) were used for the univariate analysis comparing the two patient groups with CHTKA or PHTKA. A multivariate logistic regression model was used to determine the individual effect of preoperative variables (demographic, functional), and the type of HTKA (central or posterior) on the risk of HTKA revision (represented by an adjusted odds ratio). The Akaike Information Criterion (AIC) [24] was used for the adjustment of the final multiple logistic regression model. A Cox proportional hazards regression model was used to identify predictors of survival without HTKA revision. The survival probability of HTKA without revision (mean, SD) was calculated using the Kaplan-Meier method. The survival of each HTKA group (posterior and central) were compared using the log-rank test. *P* values of <.05 were considered statistically significant. All statistical analyses were performed using R software (version 3.3.2, R Core Team 2013. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria).

## **3. Results.**

### **3.1 Patients.**

The study population consisted of 32 males and 21 females with a mean age of 69 years (39–89). The mean follow-up was 51 months (1–139) with a median of 50 months. The mean follow-up for CHTKA was 25 months (1–134, SD = 11) and 50 months for PHTKA (1–139, SD = 36) (Table 1).

### **3.2 Survival analysis.**

The overall survival rate was 90% ± 8 (82.1–99.8) at 6 months, 84% ± 13 (71–94.7) at 12 months, and 81% ± 13 (71–93.2) at 60 months (Figure 3). The survival rate of CHTKA was 89.8% ± 10 (79.6–100) at 6 months, 77.7% ± 14 (63.3–95.4) at 12 months and 77.7% ± 14

(63.3–95.4) at 60 months. The survival rate of PHTKA was  $90.5\% \pm 11$  (78.8–100) at 6 months,  $85.7\% \pm 13$  (72–100) at 12 months and  $85.7\% \pm 13$  (72–100) at 60 months.

The difference in survival rates between both groups was not statistically significant ( $P = .625$ ).

### 3.3 Clinical and radiological evaluation

Joint mobility was better in the CHTKA group ( $P = .006$ ), as were the VAS ( $P < .001$ ), IKS ( $P = 0.03$ ) and IKS stair subgroup ( $P = .01$ ) (Table 2).

#### Radiographic findings.

No statistically significant differences were observed (Table 2).

### 3.4 Revisions.

Thirteen patients required a second operation, i.e. 25% (Table 2). The complication in the CHTKA group was a cutaneous necrosis with a coverage procedure. The etiologies for revision were: one dislocation, two polyethylene (PE) wear, one unexplained pain and two periprosthetic fractures. The complications in the PHTKA group were: one rupture of the knee extensor mechanism and one patellofemoral instability. The etiologies for revision were: two PE wear and two aseptic loosening (one femoral and one femorotibial) with the replacement of bipolar components.

The mean recovery time was 10.5 months for the general population (median 5 months), 4.5 months for CHTKA (median 3 months), and 17.6 months for PHTKA (median 7 months). The multivariate analysis showed that the postoperative flexion was an independent protective factor for HTKA revision (Odds Ratio (OR) = 0.92 (95% Confidence Interval (CI), 0.85–0.99),  $P = .02$ ) (Table 3).

## 4. Discussion.

The principle hypothesis that there was no significant difference in survival between the two groups was confirmed: 77.7% (95% CI, 63.3–95.4) for CHTKA versus 85.7% (95% CI, 72–100) for PHTKA at 60 months,  $P = .625$ .

In the literature, revision rates varied between 4 and 35% and complication rates between 10 and 44% (Table 4). These data are comparable to the figures reported here. These differences can be explained by the exclusion of septic revisions [24,30,31].

This is the only study in the literature to compare CHTKA and PHTKA results. Prior studies have focused on the indications, outcomes and complications of a single type of implant [10, 25-26,28-29] without a comparison.

As for the secondary outcomes: flexion was more favorable in the CHTKA group with a flexion of 101° (80–140) versus 98° (30–130) for PHTKA ( $P = .006$ ). Flexion was described as a factor of good functional outcomes [16, 32]. Furthermore, the multivariate analysis showed that postoperative flexion was correlated with a lower rate of surgical revision (OR = 0.92 (0.85–0.99),  $P = .02$ ).

Each type of implant has a different biomechanical performance depending on the clinical situation. Long et al [13] tested the properties of hinged TKA and reported that the quadriceps force at 20° knee flexion was weaker in CHTKA than in PHTKA, due to a weaker patellar ligament moment arm, that is synonymous with a functional deficit.

VAS was better for CHTKA than PHTKA (0.5 (0–6) versus 1.6 (0–4),  $P = .000008$ ), but the clinical significance of these differences is probably nil.

The retrospective nature of this study was a limitation but given the low incidence of HTKA it was the only feasible approach. This is one of the largest cohorts in the literature. The number of patients lost to follow-up was significant (52%) but similar to the literature [25,28-29]. The follow-up was short due to the lack of indications. The difference in the mean follow-up, 25 months versus 50 months, could be explained by a high variability in the follow-up data, but both populations were statistically comparable for this characteristic. The etiologies differed between the two groups. The CHTKA group was 33% larger than the PHTKA group. Therefore, the results and the small differences found in this study should be interpreted with caution. Tumor etiologies were not represented because infections, deaths and lack of follow-up led to the exclusion of these records.

However, this study does have strengths: prospective collection with a final assessment performed by an independent reviewer.

## **5. Conclusion**

No significant difference between CHTKA and PHTKA survival was found. CHTKA had better flexion, reduced VAS and superior IKS. Surgeons need to be informed of this data in order to better guide their treatment decision. However, these results should be applied with caution given the small difference between the two groups and the limitations of this study.

**Conflicts of Interest:** The authors below declare that they have no conflicts of interest directly related to this study. Outside the scope of this study, E. Cavaignac is a consultant for Arthrex. M. Ehlinger is an educational consultant for Groupe Lépine, Amplitude and Newclip, and an associate editor of the SOFCOT teaching conferences. G. Pasquier is an educational consultant for Zimmer Biomet. The other authors declare that they have no conflicts of interest outside the scope of this study.

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**Author Contributions**

Arthur Justo collected the data and wrote the article. Hugo Vilette conducted the statistical study and wrote the article. Matthieu Ehlinger reviewed and corrected the article. Gilles Pasquier reviewed and corrected the article. Pierre Laumonerie conducted the statistical study and wrote the article. Étienne Cavaignac initiated and supervised the study and wrote the article.



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**Figures and tables.**



**Figure 2:** AP and lateral X-rays of the central hinged (CHTKA) (A) and posterior hinged (PHTKA) arthroplasties (B).

TOTAL KNEE ARTHROPLASTY				
	OVERALL			P value
	N = 53	<i>CHTKA</i>	<i>PHTKA</i>	
		N = 32	N = 21	
Indication, N (%)				.2
• Primary	23 (43.4)	17 (53.1)	6 (28.6)	
• Revision	25 (47.2)	12 (37.5)	13 (61.9)	
• Trauma	5 (9.4)	3 (9.4)	2 (9.5)	
Male, N (%)	32 ± 12 (60)	16 (50)	16 (76)	.09
Age (mean)	69 ± 12 (38–89)	68 ± 13 (38–89)	70 ± 11 (41–86)	1
Weight (mean)	78 ± 17 (50–122)	79 ± 15 (54–110)	77 ± 20 (50–122)	.4
BMI (kg/m <sup>2</sup> ) (mean)	29 ± 5.9 (20–48)	30 ± 5.7 (20–48)	29 ± 6.4 (21–45)	.7
Right side, n (%)	32 (60)	17 (50)	15 (71)	.3
Mean follow-up (months ± SD)	51 ± 40 (1–139)	25 ± 11 (1–134)	50 ± 36 (1–139)	.1

*N = Number of cases; BMI = Body Mass Index; SD = Standard Deviation*

**Table 1.** Description of general population demographics.

	OVERALL N = 53	TOTAL KNEE ARTHROPLASTY		P value
		CHTKA	PHTKA	
		N = 32	N = 21	
<b>CLINICAL EVALUATION</b>				
VAS	0.9 ± 1.2 (0–6)	0.5 ± 1 (0–6)	1.6 ± 0.97 (0–4)	<b>.000008</b>
Flexion (°)	100 ± 18 (30–140)	101 ± 15 (80–140)	98 ± 22 (30–130)	<b>.006</b>
<b>Functional SCORES</b>				
Devane	2.9 ± 1 (1–5)	2.8 ± 0.92 (1–5)	3.1 ± 1.1 (1–5)	.2
Charnley	3 ± 1.6 (1–6)	3 ± 1.7 (1–6)	3.1 ± 1.4 (1–6)	.3
Oxford	28 ± 7.8 (6–48)	29 ± 9.1 (6–48)	27 ± 5.3 (16–36)	.3
<b>IKS TOTAL</b>	94 ± 34 (0–200)	103 ± 36 (15–180)	81 ± 31 (-9–200)	<b>.03</b>
IKS Knee	54 ± 21 (1–100)	56 ± 20 (11–100)	50 ± 15 (1–100)	.4
Pain	17 ± 15 (0–50)	18 ± 9 (0–50)	17 ± 12 (0–50)	.8
Mobility (°)	19.4 ± 4.9 (0–25)	20.2 ± 2.9 (10–25)	18 ± 1.8 (0–25)	.4
IKS stability	14.4 ± 2 (5–15)	14.1 ± 0.88 (5–15)	15 ± 0 (15–15)	.2
Flexion deformity (°)	4.1 ± 8.3 (0–15)	3 ± 5.2 (0–10)	5.7 ± 3 (0–15)	.1
Axis	1.5 ± 5.3 (0–20)	1.9 ± 5.9 (0–20)	1 ± 4.4 (0–20)	.6
IKS Function	41 ± 29 (5–100)	47 ± 27 (5–90)	31 ± 26 (-20–100)	<b>.03</b>
Walking	22 ± 11 (0–50)	23 ± 11 (0–40)	21 ± 11 (0–50)	.3
Stairs	26 ± 14 (0–50)	30 ± 12 (0–50)	21 ± 11 (0–50)	<b>.01</b>
Crutches	8 ± 6 (0–20)	6.2 ± 5.8 (0–20)	21 ± 4.3 (0–50)	<b>.02</b>
<b>X-RAY</b>				
HKA	174 ± 7.3 (155–190)	174 ± 0.3 (161–190)	173 ± 0.5 (155–180)	0.9
Patellar height	0.81 (0–1.6)	0.8 (0–1.5)	0.82 (0–1.6)	1
Femoral osteolysis	4	2	2	1
Radiolucent line	5	0	5	0.4
<b>COMPLICATIONS</b>				
Revision	10 (19)	6 (20)	4 (19)	1
Complication	3	1	2	1

N = number of cases; HKA: Hip Knee Ankle

Table 2: Comparison of postoperative results between both groups.

<b>Variables</b>	<b>Adjusted Odds Ratio (95% CI)</b>	<b>P value</b>
Hinged TKA		
• Central	Reference	
• Posterior	1.11 (0.16–7.6)	.6
Age	1 (0.91–1.1)	.93
Sex		
• Male	Reference	
• Female	6.98 (0.93–53)	.06
BMI (kg/m <sup>2</sup> )	1.04 (0.85–1.2)	.67
Side		
• Right	Reference	
• Left	1.04 (0.07–16)	.98
Postoperative flexion	0.92 (0.85–0.99)	<b>.02</b>
Charnley score	1.26 (0.58–2.3)	.46
HKA angle	1.10 (0.88–1.5)	.41
IKS	1.00 (0.98–1)	.91
Oxford knee score	1.14 (0.88–1.34)	.88
Devane score	1.01 (0.5–2)	.48

*HKA: Hip Knee Ankle*

Table 3: Independent revision risk factors for hinged TKA.

Authors	Numbers	Mean age	HTKA implant	Mean follow-up (Month)	Revision (%)	Complications (%)	Flexion Pre/Postop	RL (%)	KSS Pre/Postop
<b>Rand et al [25]</b> 1987	38	64	Posterior	50	NR	44%	76°/102°	47	14 excellent
<b>Barrack et al [12]</b> 2000	14	69	Posterior Central	51	NR	20	78°/93°	0	41 / 131
<b>Pour et al [26]</b> 2007	44	72	Posterior	50.4	16	34	NR	0	29 / 74
<b>Joshi et al [27]</b> 2008	78	72	Central	94	10	27	97°/104°	5	38 / 86
<b>Gudnason et al [28]</b> 2011	42	72	Central	105	35	21	NR/108°	12	NR/85
<b>Neumann et al [29]</b> 2012	24	67	Central	56	4	10	72°/116°	0	25 / 91
<b>Toulouse</b>	53	69	Posterior Central	51	19	25	NR/100°	4	NR/94

**RL:** Radiographic Loosening; **NR:** Not Reported; **KSS:** Knee Society Score.

Table 4: Literature between 1987 and 2015 covering hinged TKA.



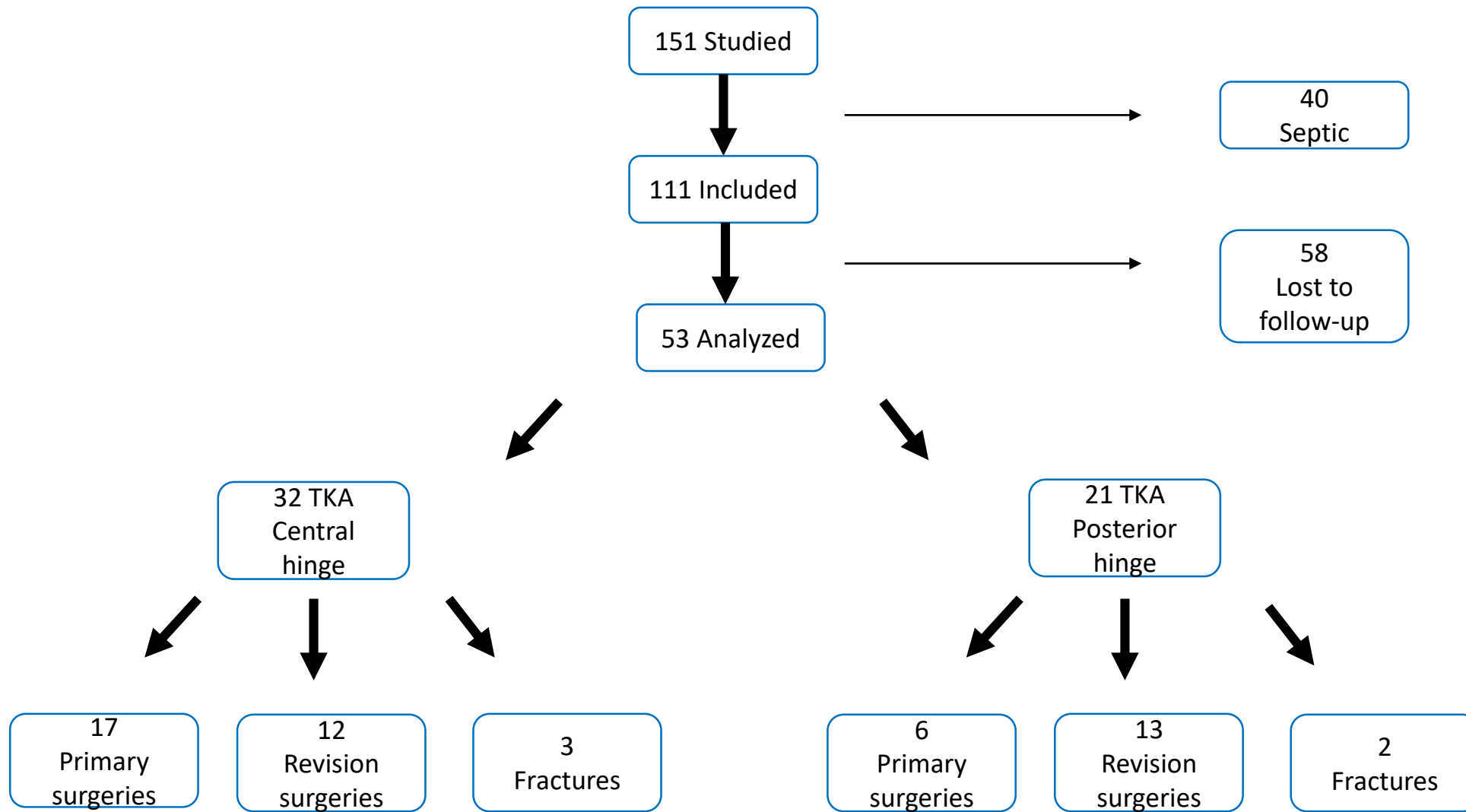
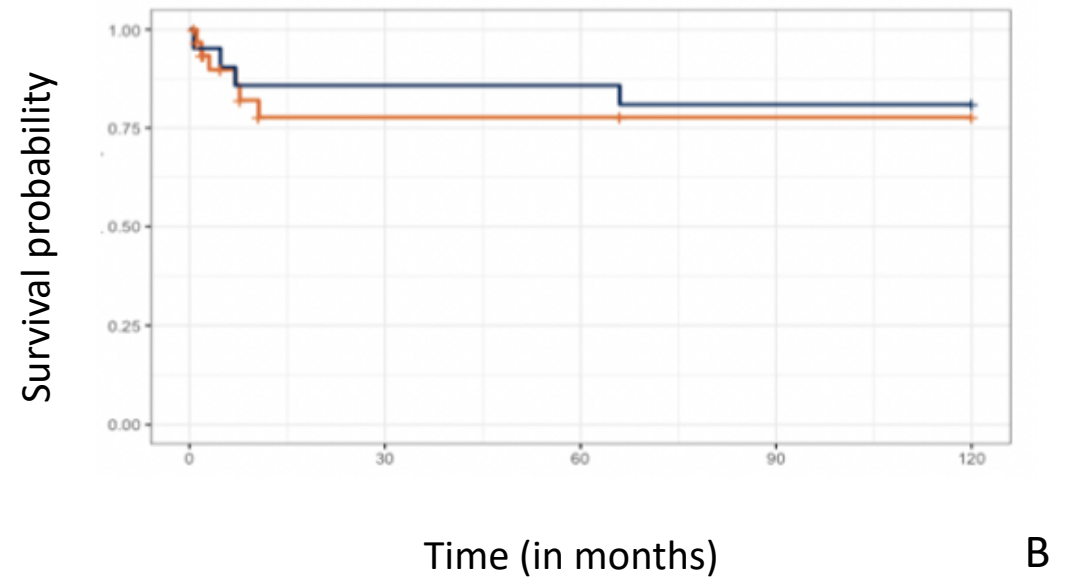
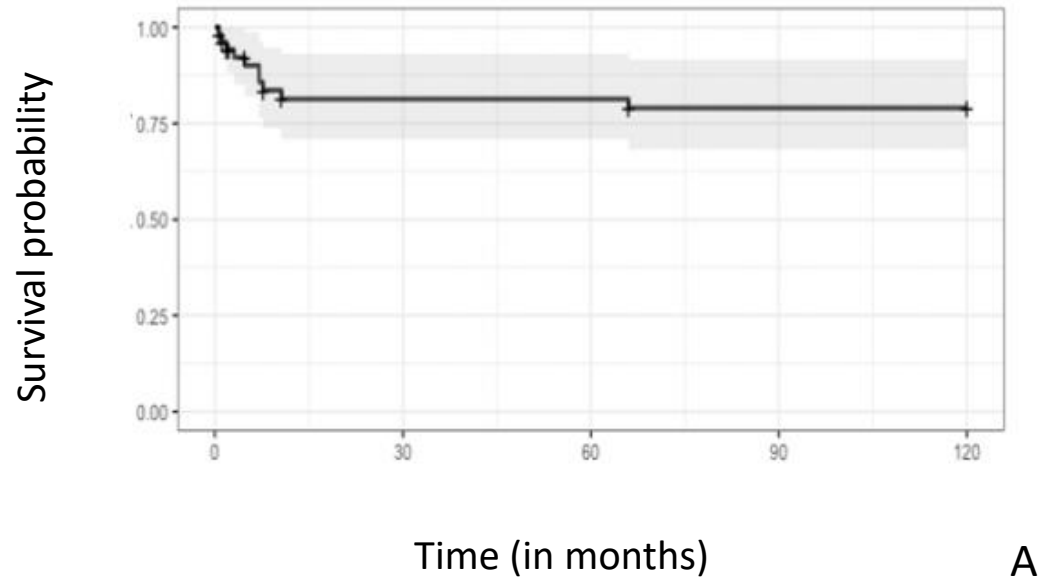


Figure 1: Flowchart



**Figure 3:** Overall Kaplan-Meier survival curve (A) or according to implant (B) (orange: CHTKA (RHK); blue: PHTKA (MRH)); events correspond to any reasons for surgical revision.