

Does computer-assisted surgery influence survivorship of cementless total knee arthroplasty in patients with primary osteoarthritis? A 10-year follow-up study

Hervé Ouanezar¹ · Florent Franck¹ · Alexandre Jacquet¹ · Vincent Pibarot¹ · Julien Wegrzyn^{1,2}

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Abstract

Purpose Computer-assisted surgery (CAS) has been proposed to improve the performance of total knee arthroplasty (TKA) by reducing implant mal-position and mechanical axis mal-alignment. However, no clinical study has been performed to evaluate whether CAS improves survivorship of cementless TKA at long-term follow-up. This prospective and comparative study evaluated the outcome and survivorship of a cementless rotating mobile-bearing TKA performed with or without CAS at a minimum 10-year follow-up.

Methods A continuous series of 138 TKA (SCORE[®], Amplitude, Valence, France) comparing 87 CAS TKA versus 51 conventional mechanical technique (MECA) TKA was prospectively included in our total joint registry.

Results At 10.5 years after implantation, 95 TKA (59 CAS and 36 MECA TKA) were evaluated. No significant difference was detected in the clinical outcome and mechanical axis between the two groups. The overall 10-year survivorship using revision for any reason as end-point was $91 \pm 5\%$ without significant difference detected between the two groups [$86 \pm 10\%$ in the MECA group and $94 \pm 5\%$ in the CAS group (n.s.)]. Using aseptic loosening as end-point, the 10-year survivorship was 100% in both groups. Using secondary patellar resurfacing as end-point, the 10-year survivorship was significantly higher in

the CAS than in MECA group (100 and $85 \pm 15\%$, respectively; $p = 0.0039$).

Conclusion With no implant aseptic loosening or mechanical failure at 10.5 years after implantation, the cementless rotating mobile-bearing SCORE[®] TKA demonstrated favourable survivorship without influence of CAS. However, CAS might influence TKA survivorship by limiting secondary patellar resurfacing.

Level of evidence Therapeutic, Level II.

Keywords Total knee arthroplasty · Computer-assisted surgery · Cementless fixation · Survivorship · Secondary patellar resurfacing

Introduction

Although cemented fixed-bearing total knee arthroplasty (TKA) is still considered as the gold-standard procedure, cementless mobile-bearing TKA has been proposed as an alternative in an attempt to reduce mechanical failure of implant fixation and aseptic loosening at long-term follow-up, particularly in younger patients [2, 13, 15, 23, 28]. The rationale of cementless mobile-bearing TKA is to reduce contact stress within the implants and subsequent polyethylene (PE) wear, to minimise mechanical forces transferred to the bone–implant interfaces and to overcome—with a biologic fixation—the potential osteolytic effects of PE wear [1, 21]. Modern series focused on cementless TKA outcome reported survivorship up to 96% at 12.4-year follow-up without significant difference in long-term survivorship between cementless and cemented TKA demonstrated in meta-analyses [22]. More than implant fixation or bearing systems, other parameters such as the design of the prosthetic trochlear groove, patellar resurfacing, bone

✉ Julien Wegrzyn
julien.wegrzyn@chu-lyon.fr

¹ Department of Orthopedic Surgery – Pavillon T, Hôpital Edouard Herriot, Hospices Civils de Lyon, 5, Place d'Arsonval, 69437 Lyon, France

² INSERM UMR 1033, Université de Lyon, Lyon, France

cuts, ligament balancing and restoration of an anatomic mechanical axis could influence survivorship [20, 25, 36]. To control some of these parameters during surgery, computer-assisted surgery (CAS) has been developed to minimise outliers in component positioning and to improve final mechanical alignment and ligament balance [10, 27, 32]. Meta-analyses tend to demonstrate that improvement in component positioning and mechanical alignment could be achieved with CAS; however, the influence of CAS on TKA clinical outcome and survivorship at long-term follow-up remains controversial [4, 10, 20, 22].

Previous prospective series comparing CAS versus conventional mechanical TKA reported encouraging results of CAS at short-term follow-up or included a limited number of patients for those with a follow-up close to 10 years or reported the use of navigation system prototype [10, 32, 40]. To our knowledge, no prospective and comparative study has been designed to evaluate the long-term outcome and survivorship of a cementless mobile-bearing TKA with selective patellar resurfacing performed using a CAS or using a conventional mechanical technique. Therefore,

this prospective study aimed to compare the outcome and survivorship of CAS versus mechanical SCORE® TKA (Amplitude, Valence, France) performed with a selective patellar resurfacing at a 10-year minimum follow-up. The use of CAS was hypothesised to improve outcome and survivorship of cementless TKA and to reduce revisions associated with implant fixation failure or patello-femoral (PF) complications.

Materials and methods

From 2002 to 2004, a continuous series of 128 patients [138 TKA; 88 women, 40 men, mean age = 70 ± 8 years and mean body mass index (BMI) = 30.5 ± 5.5 kg/m²] who underwent TKA for primary knee osteoarthritis using a cementless mobile-bearing SCORE® TKA (Amplitude, Valence, France) were prospectively included in our institutional total joint registry according to the methods proposed in the literature (Fig. 1) [5]. The exclusion criteria were TKA performed for post-traumatic osteoarthritis,

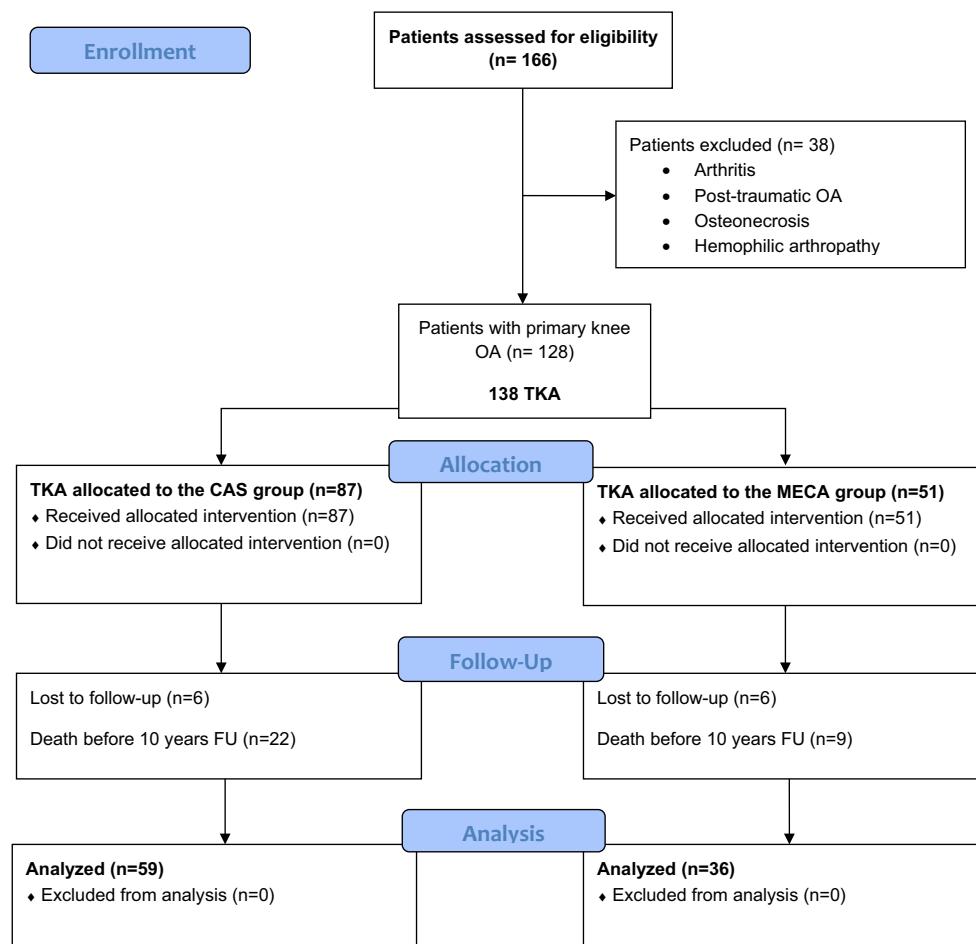


Fig. 1 Flow diagram illustrating patients' enrolment, allocation, follow-up and analysis [5]

inflammatory and micro-crystalline rheumatism, osteonecrosis and haemophilic arthropathy. Fifty-one SCORE[®] TKA were implanted using a mechanical conventional technique (MECA group; Fig. 1). Eighty-seven SCORE[®] TKA were implanted using a CAS technique with a passive imageless navigation system (AMPLIVISION[®], Amplitude, Valence, France) dedicated for the SCORE[®] TKA (CAS group; Fig. 1). In addition, a staged-bilateral TKA was performed with the same technique in four patients in the MECA group and ten patients in the CAS group (n.s.). No randomization was performed for CAS or MECA group assignment. However, the choice of the technique for TKA was defined peri-operatively according to the operating room where the TKA was performed since only one was equipped with a navigation system at the time of the study. The patella was selectively resurfaced in 52 TKA in cases of severe patellar cartilage erosion (Outerbridge grades III and IV), and patellar instability and mal-tracking (28 TKA in the MECA group versus 24 TKA in the CAS group, $p = 0.003$) [30]. Patellar instability and mal-tracking was investigated intraoperatively with the trial components, and the patella was resurfaced in case of decentred tracking onto the femoral component trochlear groove, lateral sub-luxation or dislocation persistent after patellar reticulum balance. At a minimum 10-year follow-up, 20 patients (22 TKA, mean follow-up = 102 ± 19 months) in the CAS group and 9 patients (9 TKA, mean follow-up = 88 ± 39 months) in the MECA group died of causes that were unrelated to the TKA (Fig. 1). In addition, 6 patients (6 TKA, mean follow-up = 16 ± 20 months) in the CAS group and 4 patients (6 TKA, mean follow-up = 20 ± 37 months) in the MECA group were lost to FU (Fig. 1). Therefore, 59 CAS TKA and 36 MECA TKA were prospectively evaluated and compared at a minimum 10-year follow-up (Fig. 1). No significant difference was detected between the two groups in terms of age, gender, BMI, knee deformity, Ahlback's stage of osteoarthritis and preoperative Knee Society Score (KSS; Table 1).

The SCORE[®] TKA (Amplitude, Valence, France) was introduced in 2002 at our institution and can be implanted using a dedicated passive imageless CAS technique or a conventional mechanical technique. The SCORE[®] TKA is a cementless ultracongruent mobile-bearing total knee system with an anatomic trochlear groove that aims to prevent patellar instability and mal-tracking, and allows selective patellar resurfacing [12]. The cast of the implants is cobalt–chromium alloy with porous titanium plasma spray–hydroxyapatite (HA) double coating. The PE insert is made of GUR1050 ultra-high molecular weight PE sterilized under vacuum pressure with 30 kGy of γ -irradiation from a ⁶⁰Co source. The PE insert is ultracongruent and mobile in rotation. All the TKA were performed by or under the supervisions of two senior surgeons without

Table 1 Patients' baseline demographics

	MECA TKA (51 TKA)	CAS TKA (87 TKA)	<i>p</i>
Age (years)	69 ± 9	71 ± 8	n.s.
Gender (♂/♀)	13/38	30/57	n.s.
BMI (kg/m ²)	31 ± 6	30 ± 5	n.s.
Knee deformity			
Varus (°)	170 ± 5	170 ± 5	n.s.
<i>N</i> patients	42	74	n.s.
Valgus (°)	188 ± 5	188 ± 4	n.s.
<i>N</i> patients	9	13	n.s.
Global KSS (#/200)	87 ± 28	95 ± 23	n.s.
Function KSS (#/100)	50 ± 22	56 ± 17	n.s.
Knee KSS (#/100)	38 ± 13	39 ± 12	n.s.
Ahlback's classification			n.s.
Stage 1	0	0	
Stage 2	8	9	
Stage 3	31	54	
Stage 4	7	10	
Stage 5	5	14	

KSS Knee Society Score, BMI body mass index, MECA TKA TKA implanted using a conventional mechanical technique, CAS TKA TKA implanted using computer-assisted surgery, n.s. non-significant *p* value

tourniquet and through a standard medial parapatellar approach regardless of the preoperative knee deformity. All patients had peripheral nerve blockade with an indwelling femoral nerve catheter preoperatively. Intraoperative anaesthesia was performed with spinal or general anaesthesia at the discretion of the anaesthesiologist. For both MECA and CAS TKA, the aims to achieve were restoration of a neutral mechanical alignment of $180^\circ \pm 3^\circ$, symmetric gaps in flexion and extension, and a centred and stable patellar tracking. A mechanical conventional technique was used to implant 51 TKA. Tibial bone resection was determined by the deformity: 10 mm under the lateral plateau for a varus deformity and 7 mm under the medial plateau for a valgus deformity. Gaps in extension and flexion were evaluated before the femoral bone resection with a symmetric 10-mm spacer, and ligament and soft tissue release was eventually performed in a stepwise fashion in order to obtain an optimal ligament tensioning. For the femoral bone resection, a 5-in-1 jig was used with a valgus of 7° for a varus deformity and 5° for a valgus deformity. A CAS technique using a ligament referencing technique was used to implant 87 TKA. The CAS technique (AMPLIVISION[®], Amplitude, Valence, France) was composed by passive infrared sensors fixed into the femur and the tibia by threaded bone pins. A “bone morphing” of distal femur and proximal tibia was performed

intraoperatively with a special probe. The mechanical axis and angle deformity of the knee were determined with the acquisition of anatomic landmarks (i.e. centre of rotation of the hip, centre of the medial and lateral posterior femoral condyles, centre of the medial and lateral tibial plateaus and tip of the medial and lateral malleoli). Tibial bone resection was performed first according to the deformity and checked using the CAS system. Then, tibiofemoral gaps in flexion and extension, and ligament tensioning were evaluated using the CAS system with a symmetric 10-mm spacer. Ligament and soft tissue release was eventually performed in a stepwise fashion in order to obtain an optimal tensioning. The femoral bone resection was performed using a 5-in-1 jig according to the parameters defined using the CAS system (i.e. varus/valgus alignment, internal/external rotation, lateralization of the femoral component) and then checked. After implantation of the trial components, restoration of the mechanical axis, ligament balance and range of motion (ROM) of the knee were evaluated using the CAS system. Dynamic patellar tracking was carefully investigated intraoperatively with the trial components and balanced whether necessary with a lateral release or medial reefing procedure. Patients were admitted to the hospital after surgery, and a 3- to 5-day stay was routine. All patients received routine peri-operative antibiotic prophylaxis and appropriate anticoagulation for deep venous thrombosis prophylaxis. No peri- or immediate post-operative complications were reported. The same post-operative physical rehabilitation protocol was used for each patient regardless of the group. Structured physical therapy was begun the day after surgery and continued during the in-hospital stay. The patients were instructed to sit up at the bedside the evening of their surgery and to begin ambulating with assistance the day after surgery. Active ROM was encouraged and full weight-bearing ambulation was allowed on post-operative day 2 when quadriceps inhibition from the femoral nerve block had ceased. Discharge was allowed when patients could ambulate 30 m, could ascend and descend three steps, and had pain well controlled with oral medications. Patients were sent home with specific knee ROM exercises and encouraged to seek formal physical therapy on an outpatient basis two or three times per week for the first month.

Patients returned for post-operative follow-up visits at 6 weeks, 3 months, 6 months, 1 year and yearly thereafter. At latest follow-up, the evaluation was performed by a single surgeon not involved in any aspect of these patients' management, care or rehabilitation. In case of inability to attend to the yearly visit, patients were contacted by phone calls and radiographs were prescribed and sent to the evaluating surgeon. The pre- and post-operative evaluations entailed a physical examination with specific

evaluation according to Knee Society Score (KSS) with particular attention to anterior knee pain and PF symptoms [17]. Patient's satisfaction was evaluated using a 4-point Likert scale (i.e. very satisfied, satisfied, disappointed and non-satisfied). Standard weight-bearing antero-posterior and lateral radiographs, full weight-bearing long-leg radiographs and PF Merchant view of the operated knee were obtained pre- and post-operatively. The radiographs at 6 weeks were considered as baseline radiographs for post-operative follow-up comparison. At latest follow-up, comparative radiograph analysis was performed to identify radiolucent lines or osteolysis at the bone–implant interface and the hip–knee–ankle (HKA) angle was measured. Merchant views were compared to assessed PF complications such as centring and tilt of the patella, and progressive narrowing of the PF joint space particularly in case of non-resurfaced patella. Radiographs were assessed using our institutional software (Centricity®, GE Healthcare, Barrington, IL USA) allowing a measurement accuracy of 1 mm for distances and 1° for angles. Owing to the French regulation, patient's informed consent was not required to be included in this study.

Statistical analysis

Data descriptive statistics are presented as mean \pm SD. Qualitative variables were compared using the Chi-squared test. Quantitative and continuous variables were analysed using the following parametric tests: (1) Student's paired *t* tests for intragroup comparison of two variables and (2) two-sample *t* tests for intergroup comparison of two variables. The cumulative survivorship was analysed using Kaplan–Meier curves survival analysis with 95 % confidence intervals, and the survivorship between the two groups was compared using the log-rank test. Failure was defined as the revision of the TKA for any reason, aseptic loosening and secondary patellar resurfacing for PF complications. Patients' inclusion in this study was not based on an "a priori" sample size calculation. A post hoc power analysis of the hazard ratio between the CAS and MECA groups using TKA revision for any reason has been performed, and the power ($1 - \beta$) of this study was 0.21. Statistical analyses were performed using R software (version 2.14.1.) with a level of significance set at $p \leq 0.05$.

Results

The mean follow-up of the series averaged 126 ± 6 months (Table 2). At latest follow-up, the improvement in the global KSS, knee KSS and function KSS was significant in both groups ($p < 0.0001$), except for the gain in flexion,

Table 2 Pre- and post-operative clinical and radiographic evaluation of the TKA implanted using a conventional mechanical technique (MECA TKA) and using computer-assisted surgery (CAS TKA)

	MECA TKA			CAS TKA			<i>p</i> *
Follow-up (months)	127 ± 5			125 ± 8			n.s.
Patient's satisfaction (<i>n</i> , %)							
Very satisfied or satisfied	32 (89 %)			58 (98 %)			n.s.
Disappointed or non-satisfied	4 (11 %)			1 (2 %)			n.s.
	Pre-op	Post-op	<i>p</i>	Pre-op	Post-op	<i>p</i>	<i>p</i> *
Global KSS (#/200)	87 ± 28	163 ± 19	<0.0001	95 ± 23	164 ± 20	<0.0001	n.s.
Function KSS (#/100)	50 ± 22	71 ± 19	<0.0001	56 ± 17	73 ± 17	<0.0001	n.s.
Knee KSS (#/100)	38 ± 13	92 ± 6	<0.0001	39 ± 12	91 ± 8	<0.0001	n.s.
Knee flexion (°)	113 ± 17	114 ± 9	n.s.	113 ± 15	114 ± 10	n.s.	n.s.
Knee alignment (HKA angle, °)	172 ± 8.4	177.9 ± 3.4	<0.0001	173 ± 8.6	178 ± 2.5	<0.0001	n.s.

KSS Knee Society Score, HKA hip–knee–ankle angle, n.s. non-significant *p* value

*p** post-operative variable comparisons between MECA and CAS TKA

without significant difference detected between the two groups (Table 2). No significant difference in terms of patient's satisfaction was detected between the two groups (Table 2). The radiographic evaluation demonstrated a significant improvement in the mean post-operative HKA angle in both groups ($p < 0.0001$) without significant difference between the two groups (Table 2). Ten TKA (32 %) in the MECA group and 13 TKA (23 %) in the CAS group were considered as alignment outliers since their post-operative HKA angle was outside the anatomic range of $180^\circ \pm 3^\circ$ without significant difference detected between the two groups. No radiolucent lines, osteolysis or evidence for aseptic loosening was observed in both groups at latest follow-up. Ten TKA required revision: anterior knee pain in five cases, supracondylar femoral fracture in two cases, peri-prosthetic infection in two cases and stiffness in one case. Among the five TKA revised for anterior knee pain, three revisions were performed in the MECA group for isolated secondary patellar resurfacing and two revisions were performed in the CAS group: one for an over-sizing of the femoral component requiring isolated femoral component revision and one for a patellar over-stuffing of a primary patellar resurfacing requiring isolated patellar component revision. Importantly, no secondary patellar resurfacing was performed in the CAS group at latest follow-up.

At 10-year post-implantation, the overall survivorship of the SCORE® TKA using revision for any reason as end-point was $91 \pm 5\%$ without significant difference detected between the two groups [$86 \pm 10\%$ in the MECA group and $94 \pm 5\%$ in the CAS group (n.s.)] (Fig. 2). Using aseptic loosening as end-point, the 10-year survivorship was 100 % in both groups. Importantly, using secondary patellar resurfacing as end-point, the 10-year survivorship was significantly higher in the CAS group than in MECA group (100 and $85 \pm 15\%$, respectively; $p = 0.0039$; Fig. 3).

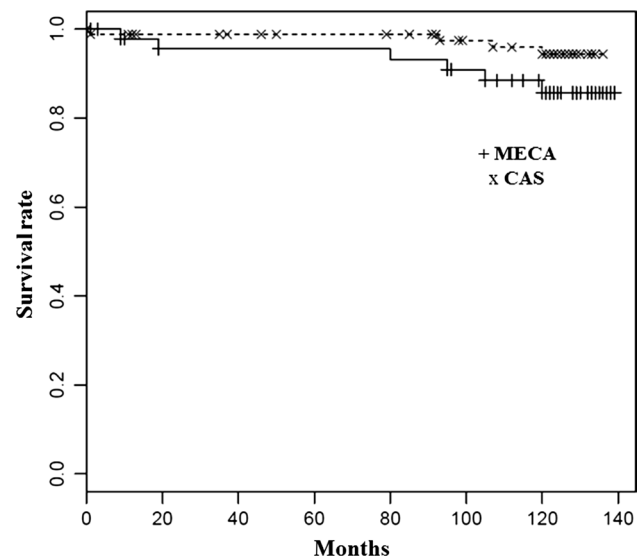


Fig. 2 Comparative Kaplan–Meier survivorship curves of MECA and CAS SCORE® TKA using revision for any reason as an end-point (MECA TKA TKA implanted using a conventional mechanical technique, CAS TKA TKA implanted using computer-assisted surgery)

Discussion

The most important finding of the present study was that favourable long-term fixation and survivorship could be achieved with a cementless ultracongruent rotating mobile-bearing TKA in patients with primary osteoarthritis without significant influence of CAS at 10-year follow-up. To our knowledge, the current study was the first designed to prospectively compare the outcome and survivorship of a single design of cementless ultracongruent mobile-bearing TKA with selective patellar resurfacing performed using a CAS technique or a conventional mechanical technique

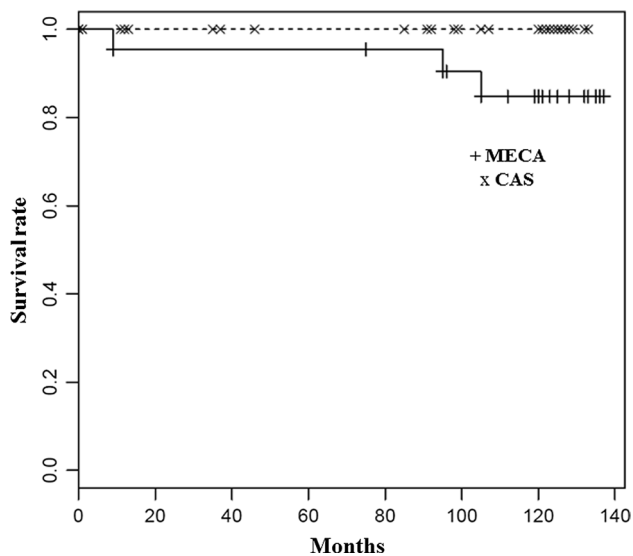


Fig. 3 Comparative Kaplan–Meier survivorship curves of MECA and CAS SCORE[®] TKA using secondary patellar resurfacing as endpoint (MECA TKA TKA implanted using a conventional mechanical technique, CAS TKA TKA implanted using computer-assisted surgery)

at a minimum 10-year follow-up. Overall, the outcome and the 10-year survivorship of the SCORE[®] TKA were comparable to previous series focused on cementless fixed- or mobile-bearing TKA [6, 8, 11, 14, 16, 33, 34, 38, 39] (Table 3). With no revision for aseptic loosening at 10.5 years after implantation, our results confirmed and strengthened those previously reported by Châtain et al. [9] demonstrating encouraging results of 447 CAS SCORE[®] TKA with no aseptic loosening at a mean follow-up of 6.6 years. In addition, Mont et al. [22] reported in a recent review a 10-year survivorship of 95.6 % with cementless TKA, which is comparable to the current series. Importantly, this review did not demonstrate any significant difference in terms of survivorship between cementless TKA and the gold-standard cemented TKA. Taken altogether, these results obtained with hydroxyapatite- or titanium porous-coated cementless TKA indicate that reliable long-term implant osseointegration and fixation could be achieved in primary knee osteoarthritis. However, caution is advised regarding the use of cementless TKA in other aetiologies characterised by a poor bone quality, such as rheumatism or haemophilic arthropathy, and further clinical studies are required.

CAS has been developed in TKA to minimise outliers in component positioning and to improve final mechanical alignment and soft tissue balance [3, 4, 9, 10, 27, 31, 40]. Châtain et al. [9] demonstrated that CAS enabled a more accurate soft tissue balance achievement and restoration of a neutral limb alignment with improved clinical scores

when compared to the conventional mechanical technique. In addition, reporting the results issued from the Australian Orthopaedic Association National Joint Replacement Registry, de Steiger et al. [35] emphasised that CAS reduced the overall rate of TKA revision as well as the rate of revision for loosening/lysis, particularly in patients less than 65 years of age in which higher rates of revision due to wear-related issues were reported in the literature. However, the influence of CAS on TKA clinical outcome and survivorship at long-term follow-up remains debated. Several studies and meta-analyses have demonstrated that positioning the TKA components within 3° of the neutral mechanical axis in the post-operative alignment of the knee could reduce the risks of early PE wear, component loosening and implant mechanical failure [3, 4, 9, 10, 27, 31]. Interestingly, Parratte et al. [24] demonstrated that achievement of a post-operative neutral mechanical axis alignment of 0° ± 3°, as is currently obtained with contemporary CAS systems, could not substantially improve TKA survivorship at long-term follow-up compared to TKA that missed this goal. This result suggests that the importance of a post-operative neutral mechanical axis could be relative compared to ligament and soft tissue balance [7, 9]. Balanced soft tissue and ligament are essential for optimal knee kinematics, and over-tensioning of ligaments could lead to reduced range of motion and increase the likelihood of flexion deformity and medial–lateral instability [37]. According to our experience, a computer-assisted ligament referencing technique such as used with the CAS SCORE[®] TKA constitutes the most accurate technique to control the ligament and soft tissue balance in relation to a specific mechanical axis intraoperatively. In the current series, no significant difference in terms of clinical scores or final mechanical alignment was detected between MECA and CAS SCORE[®] TKA. However, this result can be explained by the high-volume experience in conventional mechanical TKA of the two senior surgeons when CAS was introduced at our institution in 2002. In this way, our results were in agreement with those reported by Zhu et al. [40] in a recent randomized clinical trial comparing the outcome of minimally invasive TKA performed with CAS versus conventional mechanical TKA, demonstrating no difference in clinical, radiographic and functional outcome between the two techniques at a 9-year follow-up.

Design of the implants remains an essential parameter in TKA outcome and survivorship, especially for the PF compartment [12, 29]. Along with neutral mechanical axis restoration and equilibrated soft tissue balancing, one of the TKA goals is to restore anatomic parameters such as the PF alignment and tracking [26]. Importantly, Dejour et al. [12] demonstrated, in a biomechanical study, that the femoral component of the SCORE[®] TKA avoids the mistake of a “dysplasia design” with an optimal trochlear

Table 3 Results at a minimum 10-year follow-up of the cementless TKA reported in the literature

References	Study design	Implant evaluated (manufacturer)	Implant description	Number of TKA included	FU (years)	Overall survivorship
Buechel [8]	Prospective	New Jersey LCS (DePuy)	Cruciate retaining Mobile bearing Porous titanium coated	309	12.4	97.4 % (at 10 years)
Watanabe et al. [38]	Prospective	Omnifit 3000 (Osteonics)	Cruciate retaining Mobile bearing CoCr beads coated	76	10.5	100 % (at 10 years)
Epinette et al. [14]	Prospective	Omnifit 7000 (Osteonics)	Cruciate retaining Fixed bearing Hydroxyapatite coated	96	11	94.4 % (at 11 years)
Hofmann et al. [16]	Retrospective	Natural Knee (Zimmer)	Cruciate retaining Fixed bearing Porous titanium coated	300	12	93.4 % (at 10 years)
Whiteside [39]	Prospective	Ortholoc I (Wright Medical)	Cruciate retaining Fixed bearing CoCr beads coated	265	10	98.6 % (at 18 years)
Sorrells et al. [34]	Prospective	LCS (Depuy)	Cruciate sacrificing Mobile bearing Porous titanium coated	528	10	89.5 % (at 12 years)
Cross et al. [11]	Prospective	Active (ASDM)	Cruciate retaining Fixed bearing Hydroxyapatite coated	1429	6.6	99.1 % (at 10 years)
Schröder et al. [33]	Retrospective	AGC 2000 (Biomet)	Cruciate retaining Fixed bearing Porous titanium coated	114	10	97 % (at 10 years)
Châtain et al. [9]	Retrospective	Score (Amplitude)	Ultracongruent Mobile bearing Hydroxyapatite coated	447	6.6	96 % (at 8 years)
Ouanazar et al. Current series	Prospective	Score (Amplitude)	Ultracongruent Mobile bearing Hydroxyapatite coated	138	10.5	91 % (at 10 years)

TKA total knee arthroplasty, FU follow-up, CoCr cobalt–chromium

design that reproduces an anatomic, non-dysplastic and asymmetric trochlear groove that is deep, wide and more proximally extended. In addition, Piriou et al. demonstrated that the CAS system used with the SCORE[®] TKA allowed a reliable and reproducible method for setting the femoral component rotation during TKA with navigation of the femoral trochlea [18, 19, 26, 29]. The femoral component rotation is set intraoperatively when the component trochlea is perfectly super-imposed over the native trochlea on sunrise views at 30°, 60° and 90° of knee flexion during the simulated femoral component planning on the computer. Therefore, the component trochlea is aligned on the native trochlear groove axis which was defined during the trochlear bone morphing. This technique optimises the balance

of the medial and lateral patellar retinaculum and helps to balance the arthroplasty PF joint, thus preserving the kinematics of the extensor mechanism. In addition, the CAS system maintains a rectangular medial and lateral flexion gap to avoid ligament laxity in flexion due to the femoral component rotation. Therefore, by reducing rotational malalignment, potential negative anatomic and clinical consequences such as anterior knee pain or patellar mal-tracking could be also avoided. In the current series, the survivorship of the SCORE[®] TKA using secondary patellar resurfacing as an end-point was significantly higher in the CAS group with no revision at 10.5 years after implantation. In the context of selective patellar resurfacing, CAS could improve the restoration of the distal femoral anatomy and

important patello-femoral parameters such as the antero-posterior femoral offset, medio-lateral positioning and rotation alignment of the femoral component, and PF balance and tracking.

There are four main limitations to the current study. First, this study could be considered as statistically underpowered. However, this study reported the largest series available in the literature comparing CAS and conventional mechanical TKA with a follow-up of at least 10 years. Second, although comparative, no randomization has been performed pre- or intraoperatively to allocate patients into the MECA or the CAS group. However, no significant difference in the patients' preoperative status was detected between the two groups (Table 1). Third, 7 and 12 % of the TKA in the CAS and MECA group, respectively, were lost to follow-up despite the prospective follow-up allowed by our institutional total joint registry. Fourth, variability which could affect outcome and survivorship such as slight technical variations between the two senior surgeons was not evaluated in this study though both were high-volume knee surgeons.

Conclusion

With a 91 ± 5 % survivorship using revision for any reason and 100 % survivorship using revision for aseptic loosening as end-points, the cementless ultracongruent rotating mobile-bearing SCORE[®] TKA demonstrated favourable outcome, long-term fixation and survivorship in patients with primary osteoarthritis without significant influence of CAS at 10-year follow-up. However, CAS might influence TKA survivorship by limiting secondary patellar resurfacing.

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Compliance with ethical standards

Conflict of interest HO, FF, AJ and JW declare that they have no conflict of interest. VP declares royalties perceived from Amplitude, Valence, France.

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