Survival analysis of total knee arthroplasty at a minimum 10 years’ follow-up: A multicenter French nationwide study including 846 cases

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KEYWORDS
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Summary
Introduction: Survivorship for modern total knee arthroplasties (TKA) is not precisely known from large series, other than registries. The present retrospective study therefore analyzed 846 TKAs at a minimum 10 years’ follow-up.
Hypothesis: Ten-year survivorship for TKAs in a multicenter study exceeds 90%, independently of design and level of prosthetic constraint.

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Introduction

Total knee arthroplasty (TKA) rates have increased by 60% over the last 10 years and are expected to rise by more than 100% over the next 10 years [1]. Ten-year survivorship is a reference assessment parameter, with several reports of survivorship consistently exceeding 90% in single-center series at a minimum 10 years’ follow-up [2–4]. The present working hypothesis was that 10-year survivorship in a multicenter study would exceed 90%, irrespective of implant design or level of prosthetic constraint. Survivorship was analyzed in a retrospective multicenter nationwide study of 846 TKAs at a minimum 10 years’ follow-up, focusing on:

- implant-related factors;
- patient-related factors;
- postoperative lower-limb alignment as measured by the hip-knee-ankle (HKA) angle on telemetry.

Material and methods

Patients

The present multicenter study of TKA at 10 years’ follow-up provides a snapshot of TKA practices in France during the year 2000 in the ten study institutions. Results were collected on a computer file, and analyzed by the medical statistics department of Lille University Hospital. The cohort comprised 942 TKAs in 922 patients, with 846 TKAs having analyzable clinical and/or radiological files at the time of the minimum 10-year follow-up.

The series thus comprised 846 TKAs in 828 patients: 274 males (33%), 554 females (67%); mean age was 71 years (range, 41 to 93 years); mean pre-operative body-mass index (BMI) was 28.7 (13–50). Etiology was osteoarthritis in 753 cases (89%), inflammatory rheumatism in 69 (8%), and osteonecrosis in 24 (3%). Activity on the Devane classification [5] was 40.6% (336 patients) semi-sedentary with home activity (level 2), 40.5% (335 patients) occasionally active with light activity (level 3), 11% (91 patients) with light sports activity (level 4), 4.1% (35 patients) with strenuous manual labor and high-level sports activity (level 5), and only 3.8% (31 patients) sedentary (level 1).

Assessment

Clinically, the Knee Society (KS) function and knee scores [6] were assessed pre-operatively and at end of follow-up. Radiologically, patients systematically underwent pre-operative and follow-up AP and lateral knee X-ray, AP telemetry to calculate the mechanical lower-limb axis (HKA) [7], and femoro-patellar views in 60° flexion. Mean pre-operative KS knee score was 35 ± 20 (range: 15 to 55 points), and function score 24 ± 18 (range: 5 to 45). Mean pre-operative range of motion was 105 ± 21° (25–125°). Alignment in 66% of cases was in less than 177° varus (n = 558), in 16% in more than 183° valgus (n = 136) and between 177° and 183° in 18% (n = 152).

Surgery

The TKA implants were categorized in six families, distinguishing fixed (FB) and mobile (MB) bearings, posterior-stabilized (PS), ultracongruent (UC) or posterior cruciate retaining (CR): 254 MB Pss, 216 FB Pss, 199 MB UCs, 76 FB CRs, 63 MB CRs and 38 FB UCs. Seven hundred and four (83%) had all components cemented, 99 (12%) had cementless components and 43 (5%) had hybrid fixation using cement to fix the tibial component. The patella was resurfaced in 668 cases (79%) and non-resurfaced in 178 (21%).
Statistics

This symposium-based study had a retrospective observational design, performed in 2010 for patients operated on in 2000, with a theoretical minimum follow-up of 10 years. Data analysis used SAS 1 software (SAS Institute Inc., Cary, NC, USA). For numeric variables, descriptive statistics comprised mean with standard deviation and median with range and, for qualitative variables, number and percentage. Correlations were analyzed by Pearson and Spearman correlation coefficients. Group comparison used the Student t-test or Anova when numbers were greater than 30 and the Mann-Whitney or Kruskal-Wallis test when less than 30. Survivorship was analyzed on Kaplan-Meier curves with 95% confidence intervals, compared on the log-rank test. A Cox model correlated study parameters and survivorship.

Results

Mean KS knee score at 10 years' follow-up was 83 ± 16 (range, 74–95 points) and mean function score 74 ± 25 (range: 60 to 90): i.e., a mean gain of 48 and 50 points respectively. Range of motion improved by a mean 7°, with mean flexion of 112 ± 12 (25–125°). Crossed findings for the KS scores showed the knee score to be influenced by implant type (with the best results for MB PS and MB UC models: Table 1; P < 0.05) and patellar replacement (mean 83 points (33–100) versus 71 (5–100) in case of non-replacement [P < 0.05]).

Radiologically, mean HKA was 179.5° ± 9.8 (170–186°); 566 knees (67%) were well-aligned (177° < HKA < 183°), 211 (25%) in varus (HKA < 182°) and 69 (8%) in valgus (HKA > 183°). None of the patients who had not undergone revision surgery showed radiologic loosening at last follow-up.

There were 63 (7.5%) failures requiring revision. The main reason was implant loosening (n = 18 [29% of re-operations]) or infection (n = 16 [25%]), totaling more than half of the cases of revision; other, much rarer, causes were stiffness (n = 9), foreign-body removal (n = 7), periprosthetic fracture (n = 7: four femoral, three tibial), femorotibial instability (n = 4) and patellar complications (n = 2). There were thus 38 cases (4.5%) of re-operation for mechanical failure. Mean time to revision was 3 years, although foreign-body removal and revision for stiffness were earlier (before 1 year).

Risk factors for the main complications (infection and loosening) were sought on multivariate analysis: no correlations were found with age at surgery, gender, BMI or pre-operative femorotibial angle. There was, however, a significant (P = 0.03) correlation with Devane score [5]: infection risk increased with degree of sedentariness, while the risk of mechanical complications or aseptic loosening increased with activity. The rate of periprosthetic fracture was low (n = 7 [1.4%]).

Overall implant survivorship in the 846 patients seen at 10 years' follow-up was 92% (95% CI: 0.90–0.94) and 97% (95% CI: 0.96–0.98) when considering loosening as endpoint (Fig. 1). Analysis revealed no difference according to implant type in overall survival or survival after mechanical failure (Table 1). Likewise, there was no significant difference in survivorship between resurfaced and non-resurfaced patellas with revision for all reasons or with revision for mechanical failure as failure criterion. Analyzing survivorship according to alignment with revision for all reasons as failure criterion found a lower rate of revision surgery for HKA less than 177° (95% survivorship; 95% CI: 0.91–100) and HKA more than 183° (95% survivorship; 95% CI: 0.92–100), although the difference with respect to the group of patients with good alignment was not significant (P = 0.0579). Likewise for revision for mechanical reasons and radiologic failure without revision, the rate of revision was lower in the group of patients with malalignment (98% survivorship; 95% CI: 0.94–100) than with good alignment (94% survivorship).

**Table 1** Overall 10-year survivorship and clinical scores according to TKA family.

<table>
<thead>
<tr>
<th>TKA type</th>
<th>n</th>
<th>Survivorship (%)</th>
<th>95% CI</th>
<th>Mean KS knee score (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed CR</td>
<td>76</td>
<td>95</td>
<td>0.86–0.98</td>
<td>73 (48–100)</td>
</tr>
<tr>
<td>Mobile CR</td>
<td>63</td>
<td>91</td>
<td>0.80–0.96</td>
<td>75 (16–100)</td>
</tr>
<tr>
<td>Fixed PS</td>
<td>216</td>
<td>90</td>
<td>0.84–0.93</td>
<td>77 (33–100)</td>
</tr>
<tr>
<td>Mobile PS</td>
<td>254</td>
<td>94</td>
<td>0.90–0.96</td>
<td>92 (47–100)a</td>
</tr>
<tr>
<td>Fixed UC</td>
<td>38</td>
<td>94</td>
<td>0.78–0.98</td>
<td>87 (48–92)</td>
</tr>
<tr>
<td>Mobile UC</td>
<td>199</td>
<td>93</td>
<td>0.88–0.95</td>
<td>89 (12–100)a</td>
</tr>
</tbody>
</table>

CR: cruciate (posterior cruciate ligament) retention; PS: posterior-stabilized; UC: ultracongruent; CI: confidence interval; TKA: total knee arthroplasties.

* Significant difference.

**Figure 1** The Kaplan-Meier curve for the 846 patients analyzed at 10-year follow-up shows 92% overall survivorship.
survivorship; 95% CI: 0.90–0.97), although again the difference was not significant (P = 0.19).

### Discussion

The results of the present retrospective multicenter nationwide study of 846 TKAs at a minimum 10-years’ follow-up found overall survivorship of 92% and 97% after loosening. The wide diversity of such a cohort may constitute a study limitation, with incomplete and unsystematic data collection. The series nevertheless had the advantage of representing a large sample, in some ways representative of current practice in the year 2000. A multicenter study has the advantage of providing a snapshot of the various practices found nationwide, and a clear idea of clinical results and 10-year survivorship in the various centers, allowing prognostic criteria to be identified. At the same time, it incurs a risk of assessment bias for results measured by different observers, some of whom were the actual surgeons.

Analysis of results in terms of overall implant survivorship or survivorship after mechanical failure found no differences

### Table 2 Ten-year results of fixed-bearing total knee arthroplasties.

<table>
<thead>
<tr>
<th>Series</th>
<th>N FU/total</th>
<th>Implant</th>
<th>PS/CR</th>
<th>Age</th>
<th>Clinical score (Knee/Function)</th>
<th>10-year overall survivorship (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hoffman et al., [4]</td>
<td>176/300</td>
<td>Natural Knee™</td>
<td>CR</td>
<td>65</td>
<td>—</td>
<td>95.1% (93.2%–98%)</td>
</tr>
<tr>
<td>Barrington et al., [10]</td>
<td>87/127</td>
<td>Nexgen™</td>
<td>PS</td>
<td>70</td>
<td>94/75 (KSS)</td>
<td>97% (94%–100%)</td>
</tr>
<tr>
<td>Schwartz et al., [11]</td>
<td>126/179</td>
<td>Nexgen™</td>
<td>PS</td>
<td>62.4</td>
<td>85.4 (HSS)</td>
<td>97.7% (96.3%–99%)</td>
</tr>
<tr>
<td>Nakamura et al., [12]</td>
<td>309/507</td>
<td>Bisurface™</td>
<td>PS</td>
<td>68.5</td>
<td>93.3/52.7 (KSS)</td>
<td>97.4% (95.8%–99%)</td>
</tr>
<tr>
<td>Moutet et al., [13]</td>
<td>80/117</td>
<td>Europ™</td>
<td>CR</td>
<td>73</td>
<td>88/80 (KSS)</td>
<td>97.8% (91.5%–99.5%)</td>
</tr>
<tr>
<td>Present series</td>
<td>846/942</td>
<td>Multiple</td>
<td>PS + CR</td>
<td>71</td>
<td>83/74 (KSS)</td>
<td>92% (90%–94%)</td>
</tr>
</tbody>
</table>

N FU/total: number of patients followed up/initial number; PS: posterior-stabilized; CR: cruciate (posterior cruciate ligament) retention; KSS: Knee Society Score; HSS: Hospital for Special Surgery Score; 95% CI: 95% confidence interval.

### Table 3 Ten-year results of mobile-bearing total knee arthroplasties.

<table>
<thead>
<tr>
<th>Series</th>
<th>N FU/total</th>
<th>Implant</th>
<th>PS/CR</th>
<th>Age</th>
<th>Clinical score (Knee/Function)</th>
<th>10-year overall survivorship (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Callaghan et al. [14]</td>
<td>82/114</td>
<td>LCS™</td>
<td>PS</td>
<td>70</td>
<td>90/75</td>
<td>100% NK</td>
</tr>
<tr>
<td>Buechel [15]</td>
<td>309/309</td>
<td>LCS™</td>
<td>CR</td>
<td>71</td>
<td>—</td>
<td>97.4% (95%–100%)</td>
</tr>
<tr>
<td>Vogt and Saarbach [16]</td>
<td>59/101</td>
<td>LCS®</td>
<td>PS</td>
<td>70</td>
<td>78/66 (KSS)</td>
<td>95% NK</td>
</tr>
<tr>
<td>Metsovitis et al. [17]</td>
<td>326</td>
<td>Rotaglide™</td>
<td>UC</td>
<td>66.7</td>
<td>92.6/66.7 (KSS)</td>
<td>96% (93%–98%)</td>
</tr>
<tr>
<td>Mefta et al. [18]</td>
<td>106/138</td>
<td>LCS™</td>
<td>PS</td>
<td>69.2</td>
<td>94 (HSS)</td>
<td>97.7% (92%–99%)</td>
</tr>
<tr>
<td>Argenson et al. [19]</td>
<td>108/116</td>
<td>Nexgen Flex™</td>
<td>PS</td>
<td>69</td>
<td>94/88 (KSS)</td>
<td>98.3% (97.1%–99.5%)</td>
</tr>
<tr>
<td>Present series</td>
<td>846/942</td>
<td>Multiple</td>
<td>PS + CR</td>
<td>71</td>
<td>83/74 (KSS)</td>
<td>92% (90%–94%)</td>
</tr>
</tbody>
</table>

N FU/total: number of patients followed up/initial number; PS: posterior-stabilized; CR: cruciate (posterior cruciate ligament) retention; UC: ultracongruent; KSS: Knee Society Score; HSS: Hospital for Special Surgery Score; 95% CI: 95% confidence interval; NK: not known.
related to implant type or level prosthetic constraint. The 10-year survivorship for this prosthesis nationwide study was comparable to that reported in numerous contemporary single-center studies of TKAs with a fixed [8–13] or mobile [14–19] polyethylene component, followed up almost exclusively in the context of osteoarthritis of the knee, with nine out of ten surviving at a minimum 10 years’ follow-up (Tables 2 and 3). Clinically, the best K5 scores in the recent single-center reports [18,19], whereas this difference between fixed and mobile bearing implants was not always found in comparative studies [20]. Mean active flexion in the single-center studies ranged from 105° to 110° [8–15], slightly lower than the 112° found in the present series.

The patella was very seldom implicated in complications in the present series. Survivorship analysis found no significant difference between resurfaced and non-resurfaced patellas for revision for all reasons or revision for mechanical failure, in agreement with the various comparative studies [21,22] and meta-analyses [23,24]. In the current series, activity was the only patient-related factor affecting 10-year survivorship [25], with a greater risk of mechanical complications and aseptic loosening in more active patients, confirming previous findings regarding activity and long-term TKA survival [26,27].

In the current series, the objective for all surgeons was to restore a neutral mechanical axis, whether the patient had been pre-operatively in valgus or in varus. The hypothesis that TKA survival is enhanced in well-aligned patients, however, was not confirmed, whether analyzing revision for all reasons or revision for strictly mechanical causes. As shown by a recent study of the impact of the mechanical axis on long-term implant survivorship, there is at present no evidence that restoring a neutral mechanical axis, whatever the pre-operative deviation, is the right solution [28].

**Conclusion**

The working hypothesis was that 10-year TKA survivorship in a multicenter nationwide study would be greater than 90% independently of design or mechanical stress level. The present results for 846 TKAs found an overall survivorship of 92%. Analysis found no significant differences in survivorship, overall or after mechanical failure, according to model. Choices made 10 years previously, whatever the design, provided satisfactory results, with 97% survivorship after loosening. Three types of complications are to be noted: loosening, infection and stiffness. Failure analysis showed the patient to be the prime factor; the same analysis should be conducted on the functional results, given that improved patient satisfaction doubtless involves better assessment of patient expectations in total knee arthroplasty.

**Disclosure of interest**

J.-N. Argenson declares no conflict of interest for this study, but is a consultant for Zimmer and Convatec and receives funding from Stryker and Ortho and royalties from Zimmer and Symbios. S. Boisgard received financial support from Zimmer and Mathys for the present study, and is a consultant with Zimmer and Mathys and receives royalties from Euros, Zimmer and Smith & Nephew. S. Parratte declares no direct conflict of interest for this study, but is a consultant for Zimmer, Grafts and Adler Ortho and receives royalties from Euros. S. Descamps declares no direct conflict of interest for this study, but is a consultant for Zimmer and Depuy and holds a patent with Euros. M. Bercovy declares no direct conflict of interest for this study, but is a consultant for and receives royalties from Biomet. P. Bonnevialle declares no direct conflict of interest whether related or not related to this study. J.-L. Briard declares no direct conflict of interest for this study, but is a consultant for Depuy and Synthes. J. Brihault declares no direct conflict of interest for this study, but is a consultant for Tornier and Smith & Nephew and receives educational funding from Smith & Nephew and Orthofix. J. Chouteau declares no direct conflict of interest whether related or not related to this study. R. Nizard declares no direct conflict of interest for this study, but is a consultant for Ceraver and receives royalties from Zimmer. D. Saragaglia declares no direct conflict of interest for this study, but receives royalties from Braun. E. Servien declares no direct conflict of interest for this study, but receives educational funding from Tornier and Smith & Nephew.

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**References**


