



# Increased survival rate for primary TKA with tibial short extension stems for severe varus deformities at a minimum of 2 years follow-up

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## Abstract

**Purpose** The purpose of this study was to compare the clinical results, radiographic loosening and early complications between patients undergoing primary knee arthroplasty (TKA) with tibial short stem extension and those with standard stem for gross varus deformities at minimum two years after surgery.

**Methods** From a prospective TKA database of 4216 patients, patients with a primary TKA with a tibial short stem extension (30 mm) for severe varus deformity (hip-kneeankle angle, HKA < 170°) and a minimum follow-up of 2 years, were reviewed and compared to a matched control group with tibial components with a standard stem, in a 1:3 ratio. Demographics, surgical parameters, pre- and postoperative alignment and outcome parameters were collected for all patients. The primary outcome was aseptic loosening of the tibial component. Secondary outcomes were knee society scores (KSS), postoperative HKA, general postoperative complications and implant survival rates.

**Results** Forty-five patients with tibial short stem extensions (mean HKA 166.2°) were compared in a 1:3 ratio to a matched case–control group of 135 patients with standard stems (mean HKA 167.1°) at a mean follow-up of 57 and 64 months respectively after primary TKA. In the extension stem group, 4 patients encountered complications (8.9%) versus 12 patients in the standard stem group (8.9%). There were no cases of tibial component loosening in the short extension stem versus four cases in the standard stem group (3%). This difference was significant between groups,  $p = 0.04$ .

**Conclusion** In patients with varus deformities > 10°, undergoing primary total knee arthroplasty, prophylactic use of a tibial short extension stem may lead to less loosening of the tibial component. In this study, 3% of patient with big varus deformity without stemmed TKA had a tibial implant loosening versus 0% in the stemmed TKA group.

**Level of evidence** Level III, case–control study

**Keywords** Total knee arthroplasty · Gross varus · Tibial stem extension · Tibial component loosening · TKA revision

## Introduction

Reported TKA revision rates in literature are low and range between 4.9 and 7.8% at 10-years [11], with infection and aseptic loosening being the most frequently encountered

The French advisory committee on health research data processing (CCTIRS) approved this study on 24 January 2012 and 9 March 2015 (approval #11-681).

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complications [14]. Preoperative malalignment increases the risk of aseptic loosening of particularly the tibial component [13], with severe varus deformity being the most important risk factor [8, 15].

In order To distribute load transmission and reduce forces in the proximal tibia, prostheses may be equipped with pegs, keels or stems. Tibial stems further increase the mechanical stability of the tibial component by transmitting forces over the metaphysis and thereby reducing micromotion and tibial lift-off [10, 15].

Several studies have underlined the better mechanical stability of the tibial component with the use of stems, but the focus of these studies has either been on revision surgery or on complex primary cases with gross metaphyseal bone deficiency or the need for constraint [2, 10].

The implant studied here, was a posterior stabilised implant with a third condyle. This implant is known to better distribute load charge on the tibial implant [5]. For this kind of implant, is it necessary to have a stemmed TKA to decrease the tibial loosening implant rate?

The purpose of this study is to compare extension stemmed versus standard tibial components used during primary TKA in gross varus population.

The hypothesis presented is that extension stemmed TKA significantly decrease the rate of tibial loosening in gross varus population thus decreasing strength on medial compartment.

## Materials and methods

### Population

This single-centre retrospective study was based on prospectively collected data of a cohort of 4216 consecutive primary TKAs performed in the same department between November 1987 and March 2015, by multiple surgeons all of whom used the same surgical technique.

For this study two groups were compared. The first case group consisted of primary TKA's with tibial short extension stems and then a matched control group with tibial components with a standard stem. Inclusion criteria for both groups were preoperative hip knee ankle angle (HKA) < 170°, first knee surgery and minimum of 24 months follow-up (FU). Groups were matched concerning age, HKA, BMI, and sex in a 1:3 ratio. Total population for this case group consisted of 45 patients and the control group counted 135 patients (Fig. 1).

The mean FU was  $57 \pm 27$  [27–171] months in the extension stem group, and  $64 \pm 37$  [24–215] months in the standard stem group ( $p = ns$ ).

There were no significant differences between groups regarding age, BMI, preoperative HKA and gender (Table 1).

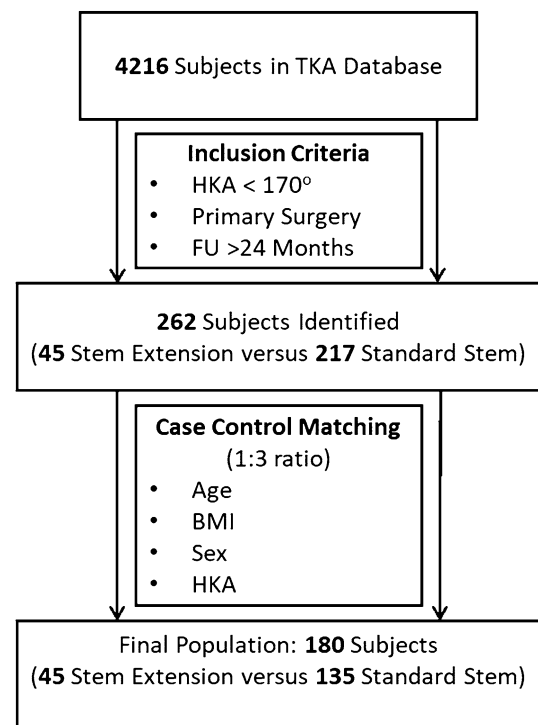


Fig. 1 Flowchart of the study

### Ethical considerations

All patients agreed to participate in this study and provided written informed consent. The French advisory committee on health research data processing (*Comité Consultatif sur le Traitement de l'Information en matière de Recherche dans le domaine de la Santé*, CCTIRS) approved this study on 24 January 2012 and then on 9 March 2015 (approval #11-681).

### Operative technique

Since 1996 the technique of a medial parapatellar approach has been systematically used for varus knee.

In this study a posterior referencing technique was used, beginning with the tibial cut and followed by the posterior femoral cut (balancing performed in flexion, then checked in extension and balanced with a distractor before the distal femoral cut). All patella were resurfaced. All the tibial implants were cemented. Instrumentation used was consistent using the same intramedullary technique. Tibial cut angle was 90°; slope was adjusted at 5°. Cutting height for tibia was adjusted at 9 mm related to the medial compartment.

Since 1987, all implants have been designed and fabricated by the same manufacturer (Wright-Tornier-Corin,

**Table 1** Preoperative population characteristics in the two study groups

|  | Total | Extension stem      | Standard stem       | <i>p</i> value |
|--|-------|---------------------|---------------------|----------------|
| Patient  | 180   | 45                  | 135                 |                |
| Female   |       | 15                  | 35                  | ns             |
| Male   |       | 30                  | 100                 |                |
| Age (years)<br>(mean ± SD) [Min; Max]              |       | 70.4 ± 7.5 [49;89]  | 72 ± 7.3 [45;87]    | ns             |
| BMI (kg/m <sup>2</sup> )<br>(mean ± SD) [Min; Max] |       | 32.1 ± 5.7 [23;50]  | 30.1 ± 4.4 [23;40]  | ns             |
| Preoperative HKA<br>(mean ± SD) [Min; Max]         |       | 166.2 ± 4 [160;170] | 167.1 ± 3 [160;170] | ns             |
| Follow-up (months)<br>(mean ± SD) [Min; Max]       |       | 57 ± 27 [27;171]    | 64 ± 37 [24; 215]   | ns             |

*BMI* body mass index, *SD* standard deviation, *Min* minimum, *Max* maximum, *ns* Non significant



**Fig. 2** Left total knee arthroplasty Kneetec with tibial component stem extension 30 × 10 mm (AP view and profile)

Montbonnot-Saint-Martin, France). All implants are similarly designed, with a posterior stabilization (HLS family implants). Tibial short extension stems measure 10 mm in diameter and 30 mm in length (Fig. 2).

### Follow-up and evaluation of tibial loosening

Clinical outcomes were assessed by determining the international knee society knee and function scores (KSS, 1989) [7]. Radiographic outcomes were assessed on weight-bearing antero-posterior, lateral, 45° patello-femoral and long-leg views. Patients underwent clinical and radiological evaluation after one year and two years, and then every two years postoperatively.



**Fig. 3** Radiograph (AP view and profile) of a right total knee arthroplasty showing tibial component loosening with a standard tibial stem

The initial diagnosis of implant loosening was made clinically and radiographically (Fig. 3). Any patient with a suspicion of implant loosening underwent blood testing (CRP and leucocytes); a CT scan to confirm loosening; bone scintigraphy searching for a focus of increased radioactive tracer uptake and a bacteriological biopsy during surgery.

If the bacteriological biopsy came back negative, aseptic loosening of the tibial implant was confirmed.

## Statistical analysis

The statistical data was analysed using the Chi-square test for the comparison of categorical variables between the two groups and the student *t*-test for the continuous variables, using the software R (R Foundation for Statistical Calculation, <https://www.R-project.org>). Survival curves were created according to Kaplan–Meier and compared with a Log Rank test, using the Technical University from Denmark's online site (<https://www.statcom.dk>). The statistical significance threshold was set at  $p < 0.05$ .

The sample size calculation showed that with a power of 80% (two sided testing at a significant level of  $p < 0.05$ ) a sample size of 31 patients was needed to show a difference between extension stemmed and standard stemmed group.

## Results

### Postoperative results (Table 2)

Postoperatively, there were no differences in tourniquet time, KSS knee scores or postoperative coronal angles between the extension stem group and standard stem group.

### Postoperative complications (Table 3)

In the short extension stem group, no cases of tibial loosening were encountered.

**Table 2** Postoperative results

|  | Extension stem     | Standard stem       | <i>p</i> value |
|--|--------------------|---------------------|----------------|
| KSS knee score (mean ± SD) [Min; Max]        | 84.9 ± 14 [50;100] | 87.3 ± 11[42;100]   | ns             |
| KSS function score (mean ± SD) [Min; Max]    | 77.2 ± 19 [40;100] | 74.8 ± 21 [0;100]   | ns             |
| Postoperative HKA (°) (mean ± SD) [Min; Max] | 175 ± 5 [157;181]  | 177 ± 3.2 [170;186] | ns             |
| Postoperative ATm (°) (mean ± SD) [Min; Max] | 87.7 ± 3 [77;91]   | 88.7 ± 2 [84;93]    | ns             |
| Tourniquet (min) (mean ± SD) [Min; Max]      | 86 ± 11 [60;105]   | 82 ± 13 [50;135]    | ns             |

*SD* standard deviation, *Min* minimum, *Max* maximum, *ns* non significant

**Table 3** Postoperative complications

| Complication     | Extension stem | Standard stem | <i>p</i> value |
|------------------|----------------|---------------|----------------|
| Total            | 4 (8.9%)       | 12 (8.9%)     | ns             |
| Patella fracture | 1 (2.2%)       | 2 (3.7%)      | ns             |
| Stiffness        | 2 (4.4%)       | 3 (2%)        | ns             |
| Laxity           | 1 (2.2%)       | 0             | ns             |
| Sepsis           | 0              | 1 (0.7%)      | ns             |
| Other            | 0              | 2 (1.5%)      | ns             |
| Tibial loosening | 0              | 4 (3%)        | 0.04           |

In the standard stem group, 12 patients presented with a complication (8.9%). Four patients of the standard stem group (3%) had tibial loosening. BMI, postoperative HKA and ATm concerning those four tibial loosening are summarized Table 4.

The difference concerning tibial loosening appeared to be statistically significant ( $p = 0.04$ ) between both groups. Details of the other complications are summarized in Table 3.

### Implant Survival Rate

In the standard stem group, the survival rate with regards to tibial component loosening is 99% at 24 months of follow-up, and 96% at 41 months of follow-up (Fig. 4).

In the extension stem group, the survival rate with regards to tibial component loosening is 100% (Fig. 5).

Using Log Rank test, no significant difference was found in survival rates of the tibial implant between both groups.

## Discussion

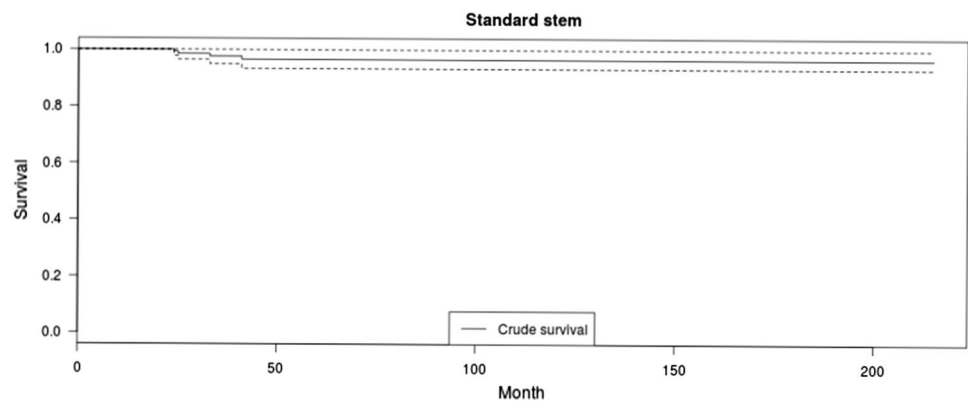
The most important finding of this study was that prophylactic use of a tibial short extension stem, in patients with gross varus deformities undergoing primary TKA, leads to less loosening of the tibial component when compared to using a tibial component with a standard stem in these cases.

However, the use of stem during primary TKA may have some disadvantages. These may include stem tip pain, risk

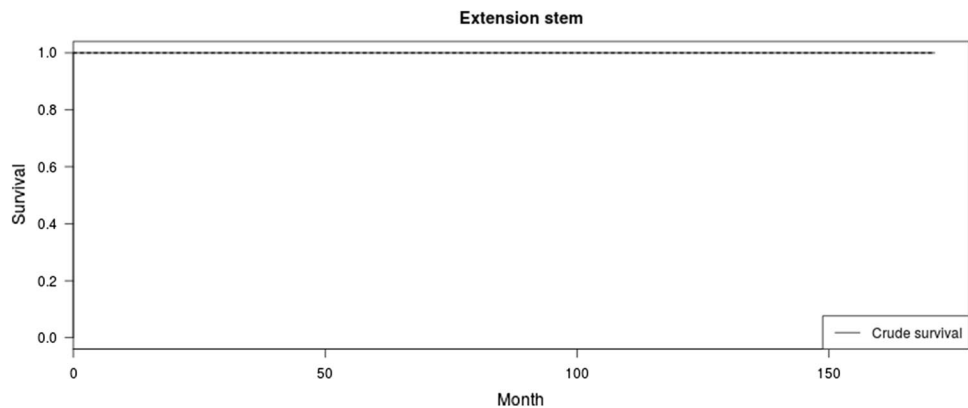
**Table 4** Data concerning the 4 patients with tibial loosening

|           | BMI (kg/m <sup>2</sup> ) | Postoperative HKA (°) | Postoperative ATm (°) | Stem     |
|-----------|--------------------------|-----------------------|-----------------------|----------|
| Patient 1 | 34                       | 179                   | 88                    | Standard |
| Patient 2 | 31                       | 179                   | 89                    | Standard |
| Patient 3 | 29                       | 189                   | 90                    | Standard |
| Patient 4 | 25                       | 178                   | 89                    | Standard |

**Fig. 4** Survival curve in standard stem group



**Fig. 5** Survival curve in extension stem group



of periprosthetic fracture or difficulty on revision if needed. However, using a short stem extension instead of a long stem extension may be considered to reduce these disadvantages by providing less bone removal.

In this study, stems used were short stems—30 mm, and stem-dependent complication was not observed in any patient. Indeed, most of stem-dependent complications observed were caused by contact with cortical bone. With short stems, no contact to cortical bone is observed.

Clinical results and complication rates appeared to be similar for both groups. These findings confirm principal hypothesis and are in accordance with literature.

Sorrells et al. [16] found that arthroplasties in patients with severe preoperative varus deformities ( $HKA < 170^\circ$ ) are more likely to fail than in neutrally aligned knees. However, they also stated that severe preoperative varus leads to postoperative malalignment, possibly contributing to failure independent of preoperative alignment. Ritter et al. [13] subsequently found that neutral postoperative alignment does improve but not eliminate the risk of failure in patients with gross preoperative malalignment ( $HKA < 172^\circ$ ), thereby directly relating severe preoperative varus deformities to a poorer outcome.

In order To improve mechanical stability and outcomes, the use of tibial stems has been extensively investigated

and described. Most studies have mainly focused on revision surgery and/or secondary prostheses [2, 4, 10, 17], but only recently attention has been drawn to the use of tibial short extension stems in primary cases.

With the use of a tibial short extension stem, Lachiewicz and Soileau [6] described excellent fixation of the tibial component. Their study did however focus on knee revision arthroplasty. Angers-Goulet et al. [1] used tibial short extension stems in 91 complex primary cases and described good radiologic and clinical results for up to seven years follow-up in a case series without control group. More recently, Park et al. [12] conducted a study amongst 88 patients (of which a bias of 87 females) with varus deformities (of less than  $8^\circ$ ) undergoing primary TKA with a tibial short extension stem and compared their radiological results to a matched control group. They concluded that using a short extension stem for the tibial component in primary TKA in patients with varus deformity ( $> 8^\circ$ ) may reduce the rate of loosening of the tibial side and increase the longevity of the implant. The results described by Park et al. are much in accordance with results found in the present study [12]. The present study however included patients with slightly larger deformities ( $> 10^\circ$ , greater than *substantial deformity* according to de Muylder classification [3]), and compared



gender-heterogeneous matched samples and presented both radiological and clinical results for the total cohort of 180 patients.

Clinical results and complications appeared similar between groups and are in accordance with literature. Noteworthy is the relative high patellar fracture rate in both groups (2.2% tibial extension stem group versus 3.7% in the standard stem group,  $p = ns$ ). This is something that was also noted by Mouton et al. [9] (2.9% patellar fractures in varus knees  $> 15^\circ$ ) and they also attributed high patella fracture rate to—devascularization during (more extensive) soft tissue release, increased constraint on the extensor mechanism after correcting varus and relative preoperative patella baja in varus knees.

There are some limitations to this study that need to be acknowledged. By nature of the retrospective study design some degree of bias could have been introduced since patients were not randomized and indication bias for the use of tibial short extension stems may have occurred. Matched control group in a 1:3 ratio was used to try to minimize bias, but not all potential confounding factors could be accounted for in the matching process (e.g. postoperative HKA).

This study has several advantages, including an important study cohort size with a significant mean follow-up of 60 months, concerning the same implant.

The authors would recommend using stem TKA for patients with severe varus deformities, for primary TKA.

## Conclusion

In patients with varus deformities  $> 10^\circ$ , undergoing primary total knee arthroplasty, prophylactic use of a tibial short extension stem may lead to less loosening of the tibial component. In this study, 3% of the patients without extension stem presented a tibial loosening versus 0% with an extension stem ( $p = 0.04$ ). No clinical difference was found.

**Author contributions** GF: study design, data collection, statistical analysis, literature review and manuscript writing. BM: literature review and manuscript writing. RG: study design and manuscript editing. CB: manuscript editing and literature review. SL: study design and manuscript editing. ES: study design, supervision, literature review and manuscript editing. All authors read and approved the final manuscript.

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## Compliance with ethical standards

**Conflict of interest** No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article. GF, BM, CB and RG declare that they have no conflict of interest. SL: consultant for Smith and Nephew, Stryker, Medacta, Heraeus, Depuy Synthes, Groupe Lepine, institutional re-

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**Ethical approval** All the procedures performed in the study were in accordance with the ethical standards of the institutional review board/international ethics committee for each center and with the 1964 Helsinki Declaration and its later amendments.

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