Comparison of cementing techniques of the tibial component in total knee replacement

Tuuli Saari · Ming Guo Li · David Wood · Bo Nivbrant

Received: 14 May 2008 / Revised: 16 June 2008 / Accepted: 17 June 2008 / Published online: 15 August 2008
© Springer-Verlag 2008

Abstract A few studies have shown that cementing the stem enhances fixation of the tibial baseplate in total knee replacement (TKR). Even the horizontal technique has been shown to provide good fixation. We used radiostereometry to study migration of the tibial component in 30 knees operated with Profix TKR. The knees were randomised for either complete (both under the baseplate and around the stem) or horizontal (only under the baseplate) cementing of the tibial component. At two years the tibial baseplate rotated externally a median of 0.18° in the uncemented stem group and internally a median of 0.23° in the cemented stem group. The tibial baseplate subsided 0.14 mm in the cemented stem group, and no translation was seen in the uncemented stem group. The differences in migration were small and probably without clinical significance. The findings do not favour either of the cementing techniques in TKR.

Résumé Peu d'études ont démontré que la fixation cimentée de la queue améliorerait la fixation du plateau tibial dans les prothèses totales du genou. Par ailleurs, les fixations horizontales ont également montré une bonne fixation. Nous avons utilisé la radiostéréométrie pour étudier la migration du composant tibial dans 30 genoux de type Profix. Les genoux ont été randomisés cimentation sous le plateau et autour de la queue ou cimentation horizontale uniquement sous le plateau. À 2 ans le plateau tibial présente une rotation externe de $0,18^\circ$

dans les PTG avec une queue non cimentée et une rotation interne moyenne de $0,23^\circ$ dans le groupe des queues cimentées. La base du plateau tibial s'enfonce de 0,14mm dans le groupe des queues cimentées et il n'y a pas de translation dans le groupe des queues non cimentées. En conclusion, la différence au niveau de la migration est minime et sans signification clinique. Cette étude ne permet pas de choisir dans les prothèses totales du genou l'une des deux techniques de cimentation.

Introduction

A stem in the tibial component decreases stress in the proximal tibia [3]. Cementing the stem could be expected to increase stress shielding in the proximal tibia [15], reduce bone mineral density and thus increase late migration. However, Hyldahl et al. showed in a radiostereometry (RSA) study that fixation was better at the two-year follow-up if the tibial stem was cemented [7, 8]. In vitro studies have shown less micromotion when complete cementing is used [2, 10, 12], but Peters et al. did not confirm this finding in a cadaver study [13].

Low migration values [1, 4, 16] and even excellent ten-year clinical results [11] have been recorded when a horizontal cementing technique has been used. Therefore cementing the stem might be questioned as this approach makes removal of the tibial component at the time of revision more difficult and may cause subsequent bone loss

As the choice of cementing technique is controversial in terms of early and long-term fixation, we aimed to measure the tibial component migrations with RSA at two years after total knee replacement (TKR) and compare the migration between horizontal and complete cementing techniques in a prospective randomised study.

T. Saari (✉)
Department of Orthopaedics,
Sahlgrenska University Hospital/Mölnal Hospital,
43180 Mölnal, Sweden
e-mail: tuuli.saari@vregion.se

M. G. Li · D. Wood · B. Nivbrant
Perth Orthopaedic Institute, University of Western Australia,
Perth, Australia

Materials and methods

The patients in this study underwent primary TKR using the cemented PROFIX Total Knee System (Smith & Nephew, Memphis, TN, USA). Exclusion criteria were inflammatory arthritis, prior tibial osteotomy or patellectomy and age greater than 75 years. The knees were randomised for either complete (both under the baseplate and around the stem) or horizontal (only under the baseplate) cementing of the tibial baseplate. The study included 38 knees: 17 had complete cementing and 21 horizontal only.

Three patients failed to attend the two-year follow-up. Furthermore, we excluded four patients in the uncemented and one in the cemented group because of inadequate quality of RSA X-rays (>0.29 for mean error or >130 for condition number), which means that we finally analysed 15 knees in each group. In the uncemented stem group the first RSA examination was obtained in three knees at six months and the migration of these components presented only between one and two years.

The operations were performed by two of the senior authors, DW and BN, using a central incision, medial approach and intramedullary guide for both femur and tibia. Palacos G[®] cement was used and the patients confined in bed for 24 hours before mobilising with weight-bearing as tolerated. Demographic data are presented in Table 1. The study was approved by the local Ethics Committee.

Radiostereometry

Four to five spherical tantalum markers (size 1.0 mm) were inserted into the proximal tibia and the polyethylene component, respectively, during surgery. RSA radiographs were taken one to three days postoperatively to establish baseline position, thereafter at six months and one and two years postoperatively. A uniplanar X-ray technique with Cage 43 and UmRSA 6.0 (RSA Biomedical, Umeå, Sweden) was used for X-rays and analysis. Radiographs were taken by using two X-ray tubes separated into 45° angulations and positioned at the knee to expose the knee simultaneously from the side.

The relative motions of the tibial component were calculated using the tibial bone markers as a fixed reference segment. Rotation around the transverse, longitudinal and sagittal axes represented migration of the tibial component and was evaluated as both signed and absolute values. Migration at two years and between one and two years was measured since the latter is prognostic for later loosening [14]. The mean condition number of the tibial bone markers was 65 (range: 34–126) and that of the polyethylene insert markers 49 (range: 21–123). The mean error of the tibial bone and insert markers were 0.17 mm (mean, range: 0.05–0.27) and 0.14 mm (range: 0.04–0.25).

Radiographic evaluation

Posterior slope and varus-valgus tilting of the tibial baseplate [5] as well as hip-knee-ankle angle (HKA) [6] were measured on X-rays.

Clinical evaluation

An independent and blinded observer measured the Knee Society knee score (KSKS) and Knee Society functional score (KSFS) [9] preoperatively and two years after the operation.

Statistics

The Mann-Whitney test was used and *p* values less than 0.05 were regarded to represent statistically significant differences. Stepwise linear regression was used to evaluate influence of age, gender, HKA and varus-valgus tilting and posterior slope of the tibial baseplate on migration.

Results

At two years the tibial baseplate rotated externally a median of 0.18° in the uncemented stem group and internally a median of 0.23° in the cemented stem group ($p=0.01$), but absolute rotation (no direction counted)

Table 1 Demographics and radiological and clinical results (mean and range)

	Cemented stems	Uncemented stems
Gender	6 female, 9 male	11 female, 4 male
Age (years)	72 (52–85)	68 (52–81)
HKA at 2 years	178° (172–182°)	180° (172–184°)
Posterior slope of tibial baseplate	1° (0–5°)	2° (0–5°)
Tilting of tibial baseplate on AP view	2° varus (5° varus to 0° varus)	1° valgus (6° varus to 2° valgus)
KSKS total score preoperatively	37 (15–57)	51 (26–91)
KSKF score preoperatively	53 (30–90)	60 (35–100)
KSKS total score at 2 years	92 (80–99)	95 (72–99)
KSKF score at 2 years	70 (20–100)	90 (50–100)

HKA hip-knee-ankle angle, AP anteroposterior, KSKS Knee Society knee score, KSKF Knee Society functional score

showed no statistically significant difference between the groups ($p=1.0$) (Tables 2 and 3). The tibial baseplate subsided 0.14 mm in the cemented stem group, and no translation was seen in the uncemented stem group ($p=0.02$), but absolute translation did not differ ($p=0.9$). No other statistically significant differences in migration were seen, $p>0.2$. We defined knees as outliers if rotation or translation at least around two axes was more than the mean value + 2 SD. In the uncemented stem group there was one outlier (translation medially 0.66 mm, subsidence 1.18 mm, rotation to valgus 1.83°), and the component was defined to be loose on the X-rays. In the cemented stem group two outliers (1: subsidence 0.41 mm, rotation to varus 0.98°, 2: translation anteriorly 0.95 mm, internal rotation 0.98°, rotation to varus 1.41°) when migration at two years was evaluated.

There were no statistically significant differences in migration between one and two years between the two groups ($p>0.09$). The migration values were generally small, but two outliers were found in both groups.

Stepwise linear regression analysis revealed that tilting of the tibial baseplate predicted translation on the longitudinal axis (adjusted $R^2=0.27$, $p=0.01$) and rotation around the sagittal axis (adjusted $R^2=0.30$, $p=0.006$). With increasing varus tilting translation on the longitudinal axis and rotation on the sagittal axis increased.

Radiographic results

Radiographic evaluation did not reveal any statistically significant differences between the groups ($p>0.2$) (Table 1).

Clinical results

The KSKS or KSFS at two years did not differ statistically between the groups ($p>0.2$) (Table 1). One patient with a cemented stem had a poor KSFS of 20 points because of severe lower back pain. Two patients had postoperative wound infection, but there had been no revisions by the two-year follow-up.

Table 2 Signed and absolute (in italics) rotations and translations of the tibial component at the 2-year follow-up (median and range)

	Cemented stems	Uncemented stems
Translation on		
Transverse axis	0.15 (−0.57–0.56), <i>0.15</i>	0.05 (−0.22–0.66), <i>0.10</i>
Longitudinal axis, $p=0.02$	−0.14 (−0.41 –0.20), <i>0.17</i>	0.01 (−1.18–0.30), <i>0.07</i>
Sagittal axis	0.14 (−0.59–0.95), <i>0.19</i>	0.01 (−0.53 –0.50), <i>0.17</i>
Rotation around		
Transverse axis	0.15 (−0.36–1.40), <i>0.22</i>	0.00(−0.84–0.92), <i>0.12</i>
Longitudinal axis, $p=0.01$	0.23 (−0.31–0.98), <i>0.24</i>	−0.18 (−0.90–0.25), <i>0.25</i>
Sagittal axis	−0.28 (−0.9–0.42), <i>0.29</i>	−0.08 (−1.83 –0.29), <i>0.17</i>

Table 3 Absolute rotations and translations of the tibial component between 1 and 2 years follow-up (median and range)

	Cemented stems	Uncemented stems
Translation on		
Transverse axis	0.09 (0.01–0.55)	0.08 (0.01–0.33)
Longitudinal axis	0.10 (0.01–0.77)	0.13 (0.02–0.47)
Sagittal axis	0.08 (0.01–0.35)	0.12 (0.01–0.46)
Rotation around		
Transverse axis	0.08 (0.00–0.32)	0.11 (0.10–0.63)
Longitudinal axis	0.06 (0.01–0.36)	0.12 (0.01–0.36)
Sagittal axis	0.15 (0.02–1.34)	0.08 (0.01–0.87)

Discussion

Whether the stem of the tibial component should be cemented remains controversial. Reducing implant micromotions and obtaining full stability of the tibial tray postoperatively reduces the risk of loosening and is hence of major importance. Some in vitro studies have shown improved fixation when cementing the stem. Bert et al. [2] reported that significant micromotion occurred if the stem was uncemented and the thickness of the cement mantle under the tray was 1 mm. If the cement mantle was 3 mm thick or the stem was cemented, the micromotion decreased significantly. Also cadaver studies by Jazrawi et al. [10] and Luring et al. [12] revealed significantly increased micromotion when only cementing the tibial baseplate. Contrary to these in vitro studies, Peters et al. did not find less micromotions when cementing the stem in cadaver knees [13]. Caution should be executed in extrapolating the results of in vitro studies to clinical practice as only a few in vitro studies show superior fixation with full cementing, and the set-up of vitro studies are quite different from the clinical situation.

Kolisek et al. reported excellent ten-year clinical results in a study on 51 TKAs with proximal cementing of the tibial component [11]. The mean Knee Society score (KSS) was 93 points, and there were progressive tibial radiolucencies in only one knee. In this study all the TKAs were secured using the horizontal cementing technique.

To our knowledge there are few earlier clinical randomised studies comparing horizontal and complete cementing techniques. Hyldahl et al. studied fixation of metal-backed and all-polyethylene tibial components and found that the migration was less at two years when using complete cementing [7, 8].

We could not confirm the results of Hyldahl et al. We found that while the tibial component rotated in different directions around the longitudinal axis, the magnitude of rotation did not differ between the groups. The reason for the difference in the direction of rotation is not clear and probably has no clinical relevance. Even translation on the y-axis differed between the groups, the cemented stems showing a median subsidence of 0.14 mm whereas the uncemented stem group had a median translation near 0 mm. However, the clinical relevance of this finding is uncertain as the migration values were low. In both groups there were knees with large migration values indicating a risk of loosening, but neither uncemented nor cemented stems were overrepresented as outliers, and migration between one and two years did not differ between the groups.

Increased varus tilt of the tibial baseplate predicted increased migration, showing the importance of proper alignment of the component.

The main drawback of our study is the small number of knees studied. Statistically significant differences might have been detected with a larger number. Furthermore, the depth of cement penetration and the thickness of the cement layer were not fully controlled.

In our study the differences in migration found between the uncemented and cemented stem groups were small. The early results of the study do not differentiate between either of these techniques; hence, we believe that a larger number of cases and longer follow-up are needed.

Conflict of interest statement The RSA examinations were supported by Smith & Nephew.

References

1. Albrektsson BEJ, Carlsson LV, Freeman MAR, Herberts P, Ryd L (1992) Proximally cemented versus uncemented Freeman-Samuelson knee arthroplasty. A prospective randomised study. *J Bone Joint Surg Br* 74:233–238
2. Bert JM, McShane M (1998) Is it necessary to cement the tibial stem in cemented total knee arthroplasty? *Clin Orthop* 35:73–78
3. Bourne RB, Finlay JB (1986) The influence of tibial component intramedullary stems and implant-cortex contact on the strain distribution of the proximal tibia following total knee arthroplasty. *Clin Orthop* 208:95–99
4. Carlsson Å, Björkman A, Besjakov J, Önsten I (2005) Cemented tibial component fixation performs better than cementless fixation: a randomized radiostereometric study comparing porous-coated, hydroxyapatite-coated and cemented tibial components over 5 years. *Acta Orthop* 76:362–269
5. Evald FC (1989) The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. *Clin Orthop Relat Res* 248:9–12
6. Hagsted B, Norman O, Ohlsson TH, Tjörnsdottir B (1980) Technical accuracy in high tibial osteotomy for gonarthrosis. *Acta Orthop Scand* 51:963–970
7. Hyldahl H, Regner L, Carlsson L, Kärrholm J, Weidenhielm L (2005) All-polyethylene vs. metal-backed tibial component in total knee arthroplasty—a randomized RSA study comparing early fixation of horizontally and completely cemented tibial components: part 2. Completely cemented components: MB not superior to AP components. *Acta Orthop* 76:778–784
8. Hyldahl H, Regner L, Carlsson L, Kärrholm J, Weidenhielm L (2005) All-polyethylene vs. metal-backed tibial component in total knee arthroplasty—a randomized RSA study comparing early fixation of horizontally and completely cemented tibial components: part 1. Horizontally cemented components: AP better fixated than MB. *Acta Orthop* 76:769–777
9. Insall JN, Dorr LD, Scott RD, Scott WN (1989) Rationale of the Knee Society clinical rating system. *Clin Orthop Relat Res* 248:13–14
10. Jazrawi LM, Bai B, Kummer FJ, Hiebert R, Stuchin SA (2001) The effect of stem modularity and mode of fixation on tibial component stability in revision total knee arthroplasty. *J Arthroplasty* 16:759–767
11. Kolisek FR, Mont MA, Seyler TM, Marker DR, Jessup NM, Siddiqui JA, Monesmith E, Ulrich SD (2008) Total knee arthroplasty using cementless keels and cemented tibial trays: 10-year results. *Int Orthop*, Jan 9, Epub ahead of print
12. Luring C, Perlick L, Trepte C, Linhardt O, Perlick C, Plitz W, Grifka J (2006) Micromotion in cemented rotating platform total knee arthroplasty: cemented tibial stem versus hybrid fixation. *Arch Orthop Trauma Surg* 126:45–48
13. Peters CL, Craig MA, Mohr RA, Bachus KN (2003) Tibial component fixation with cement: full- versus surface-cementation techniques. *Clin Orthop Relat Res* 409:158–168
14. Ryd L, Albrektsson BEJ, Carlsson L, Dansgard F, Herberts P, Lindstrand A, Regner L, Toksvig-Larsen S (1995) Roentgen stereophotogrammetric analysis as a predictor of mechanical loosening of knee prostheses. *J Bone Joint Surg Br* 77:377–383
15. Seki T, Bourgeault ST, Chareancholvanich K, Lew W, Bechtold JE, Gustilo RB (1997) Does a central stem affect bone strain and the stability of a cemented tibial tray in primary and revision TKA? *Trans Orthop Res Soc* 22:6356
16. Önsten I, Nordqvist A, Carlsson ÅS, Besjakov J, Shott S (1998) Hydroxyapatite augmentation of the porous coating improves fixation of tibial components. A randomised RSA study in 116 patients. *J Bone Joint Surg Br* 80:417–425