

Is cementing technique the cause of early aseptic loosening of the tibial component in total knee arthroplasty? A report of 22 failed tibial components

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Abstract

Despite excellent results of bicondylar knee resurfacing when both the tibial and femoral components are cemented, loosening of the cemented tibial component (surface cementing) occurs in approximately 10% of the implants within a 4-year interval after the procedure. Based on our own experience, we want to report of early failed tibial components in 22 patients after a mean follow up of 51 months. This raised the question of whether the cementing technique was implicated in the loosening. All patients were evaluated for radiolucency and osteolytic lesions at the bone-cement interfaces by radiographic assessment according to Rossi *et al.* (a.p. view and lateral view divided into two zones). A malalignment of the components, especially an increased tibiofemoral angle was not evident. The mean radiographic cement penetration in anterior-posterior view was 1.2 mm (SD 0.8) in zone 1 and 1.6 mm (SD 0.9) in zone 2. The mean radiographic cement penetration in lateral view was 1.1 mm (SD 0.4) in zone 1 and 1.3 mm (SD 0.3) in zone 2. In all cases a revision procedure was done. An infection as cause for loosening was excluded using a standardized procedure. A solid bone stock, sufficient PMMA penetration into the spongy bone promotes high initial stability and is essential for solid long term fixation of tibial components if surface only cementing technique is applied. In patients who show poor quality of the periimplant bone such as osteoporosis or osteonecrosis the authors recommend to cement both, stem and underlying surface of tibial components in primary total knee arthroplasty.

Introduction

Steady developments in the field of arthroplasty research in recent decades have led to total knee replacement becoming one of the most successful orthopedic operations. Long-term follow-up studies indicate a survival rate

of at least 90% within 15 years.^{1,2}

Nevertheless, complications that lead to failure of the prosthesis occur repeatedly. The principal causes of failure are the presence or onset of polyethylene (PE) wear, early aseptic loosening, instability, and infection.³

In the literature two main focuses were the preferred objects of investigations. Where as the surface geometry is one of the factors of failure risk, the implantation technique, especially the cementing technique is important for survival of tibial components.⁴⁻⁸

The technique employed in cementing the tibial component (surface cementing versus complete cementing) is still a matter of controversy in the recent literature. Advocates of full cementation of the tibial component (cementation of both undersurface and stem) state that this technique provides better short- and long-term fixation.⁹ On the other hand, those in favor of surface or hybrid cementation (cementation of the undersurface only) state that a sufficient implant stability is achieved, with decreased metaphyseal bone loss in case of revision and without the potential stress shielding effect.^{10,11}

The surface cementation technique demonstrated excellent mid-term results, when using fixed-bearing devices.⁹ Mobile-bearing tibial components were designed to reduce polyethylene wear and stresses across fixation interfaces.¹²

But little is known about the use of combined surface cementation and mobile bearing devices. Mobile-bearing designs showed in vitro a higher micromotion rate when fixed with hybrid technique compared to full cementation.¹³ This may result in possible early loosening, but only a few clinical outcomes of mobile bearing devices cemented in hybrid technique are reported in the literature.

Based on our own experience, we want to report of early failed tibial components in 22 patients after a mean follow up of 51 months, necessitating a revision procedure.

This raised the question of whether the cementing technique was implicated in the loosening. Every correlation between early loosening and clinically relevant covariates were investigated.

Materials and Methods

Knee system

The Genesis II CR knee replacement by Smith & Nephew is a bicondylar anatomically shaped knee arthroplasty with retention of the posterior cruciate ligament. The tibial component is an asymmetrical anatomic base plate available in different sizes. The tibial components are made of a titanium-aluminum-vana-

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dium alloy whereas the femur implants consists of a cobalt-chromium-molybdenum alloy.

The tibial component was cemented by a surface cementing technique. The polyethylene inlays were ultra high congruent mobile bearing inlays.

Patient characteristics

The mean follow up was 51 months (range: 41-58 months; SD: 7). The average age at time of surgery was 67.0 years (38-79 years, SD: 6.99 years). The average body mass index was 26.9 (Range: 21-36, SD: 8.3). All patients had a diagnosis of primary osteoarthritis of the knee, which was indicated for surgical treatment by a total knee replacement. Deformity in the frontal plane was varus in 12 knees and valgus in 2 knees. 8 knees had preoperative a neutral axis. A medio-lateral or posterior instability, an axial deviation in terms of varus or valgus leg axis of more than 10 degrees or an underlying disease which had affected the freedom of walking ability, was not evident in any of the cases.

Cementing technique

The tourniquet was inflated at the beginning of the surgical procedure. A pulsatile lavage was performed to avoid excessive bleeding during the cementation phase. Once the appropriate consistency and viscosity was achieved, the bone cement (Palacos®, Haereus) was placed directly on the undersurface of the tibial (not on the stem) and femoral components, with small amount on the posterior condyles. The tibial component was impacted in place, and the cement exceeding was carefully removed. The femoral compo-

nent was then impacted. Then, the trial insert was positioned, and the knee was kept in extension until the complete polymerization of the cement.

Postoperative rehabilitation

All patients followed the same postoperative rehabilitation protocol, starting continuous passive motion (CPM) the day after surgery and beginning full weight bearing as tolerated 2 days after surgery. CPM was continued for 3 weeks postoperatively.

Retrospective outcome assessment at follow up

Retrospectively the radiographic assessment consisted of a standing scanogram of the leg and lateral radiography to assess tibiofemoral alignment and component positioning, early postoperative (day 5) and at time of revision surgery. Additionally the radiographs were analyzed according to the study of Rossi *et al.*¹⁴ for cement penetration into the proximal tibia and for radiolucency and osteolytic lesions at the bone-cement interfaces.

The radiographs were acquired digitally with a DICOM (Digital Imaging and Communications in Medicine) standard, and the measurements were made using a DICOM viewer. The cement mantle bone penetration was measured dividing the tibial surface into 2 zones on the anterior-posterior view and in lateral view to evaluate the depth of the cement penetration (Figures 1 and 2). The cement penetration in each zone was measured with the DICOM viewer. The mean value of the measurements made by the two observers was considered. Two independent observers performed clinical and radiological assessments. Data were collected and tabulated using Microsoft Excel.

Ethical board statement

Ethical board approval of the University of Münster, Germany for the current study was waived by the ethical board. The evaluation of the current retrospective analysis was done on plain radiographs, which was already part of the patient routine follow up.

Results

The tibiofemoral angle was 5-8° valgus in 14 knee joints, 0-4° valgus in 4 joints, and 0-8° varus in 4 knee joints. The mean posterior slope of the tibia was 6.2° (SD: 2.6°). A malalignment of the components, especially an increased tibiofemoral angle was not evident.

The mean radiographic cement penetration in anterior-posterior view was 1.2 mm (SD 0.8) in zone 1 and 1.6 mm (SD 0.9) in zone 2. The

mean radiographic cement penetration in lateral view was 1.1 mm (SD 0.4) in zone I and 1.3 mm (SD 0.3) in zone 2.

All of 22 patients had osteolytic lesions around the implants, as defined by Rodriguez *et al.*⁹ These patients were unsatisfied with their knee endoprosthesis and were in need of pain killers to handle their everyday life. In all of these cases a revision surgery was done.

An infection as cause for loosening was excluded using a standardized procedure. Based on clinical presentation, haematological screening and a joint aspiration (synovial fluid diagnostic, microbiological analyses) an infection was excluded. In all cases of revision surgery (22 patients) intraoperative samples for culture and histological evaluation demonstrated no signs of infection.

Discussion

Total knee arthroplasty (TKA) remains the gold standard treatment for the end-stage degenerative joint disease of the knee, with numerous long-term follow-up studies showing an excellent survivorship of 90-95% at 15 years.^{3,15}

Nevertheless, aseptic loosening of the tibial component remains a major cause of failure. Micromotion at the implant-cement or cement-bone interface can add to the generation of wear particles, which is believed to be the main reason for this process.¹⁶

When the cementless tibial components were examined, it was apparent that complete osseointegration was absent as a result of the low primary stability (micromovements between 30-100 µm). Concerning this problem, Cameron and Jung showed in studies in 1993 that the additional use of a tibial stem on its own markedly reduced the micromovements of a cementless tibial implant, especially as it affects mediolateral movement. The authors suggested that the problem of antero-posterior micromovement might be solved by cementing the surface.^{17,18}

However, aseptic loosening of tibial components does not appear to have been solved by surface cementing. In the literature, the rate of early aseptic loosening of the tibial components (surface cementing) in a 2002 study by Sharkey *et al.* was reported as approximately 10.5% after an average interval of 4 years,¹ leading those authors to discuss the type of cementing.

To our knowledge there are only a few studies reporting clinical results of a mobile bearing total knee system using a hybrid cementing technique.^{13,14}

Most of biomechanical and clinical studies comparing surface cementing versus full cementing technique used fixed bearing

devices. The paper by Lombardi *et al.* is the only one comparing both cementation techniques using a tibial rotating platform.¹³ They described in a biomechanical study using sawbones an increased micromotion of the tibial component in mobile-bearing TKA using hybrid cementing technique (3 mm cement

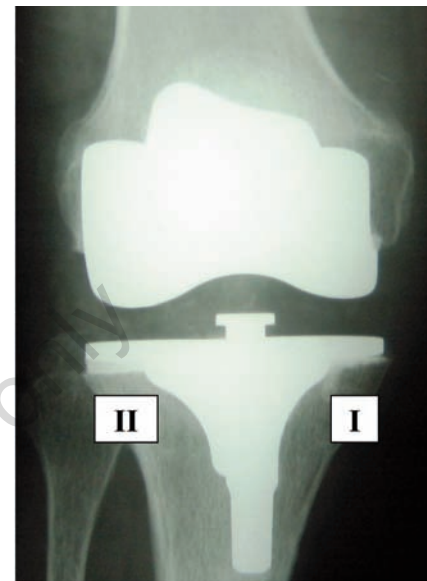


Figure 1. Antero-posterior view, divided into 2 zones (I medial; II lateral) to assess the bone-cement interface.

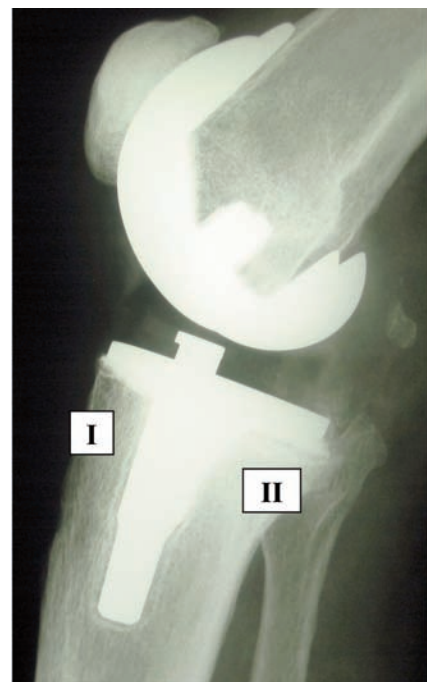


Figure 2. Lateral view, divided into 2 zones to assess the bone-cement interface (I: ventral; II: dorsal); Osteolytic lesions at the tibial stem and at the bone-cement interface.

mantle). Rossi *et al.* reported after a mean follow up of 43 months using a mobile bearing device and surface cementation ($n=70$) comparable results to other studies using different cementing techniques or surface cementing technique combine with fixed bearing devices with regard to early aseptic loosening of tibial components.¹⁴ They observed no loosening cases, but in five cases radiolucency lines around the noncemented stem were recognized which could be an early sign of aseptic loosening. We present 22 cases after a mean follow up of 51 months a symptomatic loosening of the tibial component which was primarily fixed by surface cementation.

Why do the authors have such a high rate of early loosening, using surface cementation and mobile bearing devices in total knee arthroplasties in comparison to the recent literature?

This question could not be answered by this investigation but the authors presume that the cause could be found in the way of cementation the tibial component.

Although full cementation technique is widely accepted and reported excellent and durable results,^{4,19} hybrid fixation is certainly a fascinating alternative option that may reduce the stress shielding effect on the proximal tibia and the metaphyseal bone loss in case of revision.^{20,21}

The recent literature provides a lot of biomechanical and clinical results using the surface cementation technique for fixation of the tibial and femoral components. But most of them used a fixed bearing tibial device to compare surface and full cementation of the components.

Luring *et al.* first investigated *in vitro*²² a mobile polyethylene bearing device. In cases of surface cementing the tibial component, they found a significantly increased lift-off phenomena in comparison with the completely cemented tibial components. High conformity of the polyethylene inlay, which leads to increased rotational forces, was presumed to be responsible. In order to avoid micromovements as a result of these rotational forces, and thus to counteract a likely increased risk of early loosening, the authors recommend complete cementing of the tibial stem.²²

In summary, after reviewing the recent literature, a lot of studies were found that suggest that surface cementing of the tibial component is effective and should be used as gold standard for total knee arthroplasty. Other studies suggest that complete cementing provides better stability and should be used to reduce the risk of early aseptic loosening of the tibial component.

The relevance for sufficient cementing technique was pointed out by Vanlommel *et al.* who demonstrated that applying cement only onto the tibial component, penetration is insuffi-

cient to achieve necessary fixation. Applying cement to both the undersurface of the tibial baseplate and as well as onto the tibial bone an optimal cement penetration of 3 to 5 mm could be achieved.²³

This is in accordance with previous studies which have shown that better cement penetration increases the tensile and shear strength of the cement-bone interface.²⁴ Another *in vitro* study also was able to demonstrate, that 3mm cement penetration is ideal and required to achieve at least one level of transverse trabeculae and therefore sufficient bending in the vertical channels.²⁵

Conclusions

A solid bone stock, sufficient PMMA penetration into the spongy bone promotes high initial stability and is essential for solid long term fixation of tibial components if surface only cementing technique is applied. In patients who show poor quality of the periimplant bone such as osteoporosis or osteonecrosis the authors recommend to cement both, stem and underlying surface of tibial components in primary total knee arthroplasty.

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