Revision total knee arthroplasty with the Total Condylar III system

A comparative analysis of 71 consecutive cases of osteoarthritis or inflammatory arthritis

Pu-Yi Sheng¹,³, Esa Jämsen², Matti Lehto¹,², Jorma Pajamäki¹,², Pekka Halonen¹,² and Yrjö T Konttinen¹,⁴

¹Coxa Hospital for Joint Replacement, FI-33101 Tampere, ²Medical School of the University of Tampere, Departments of ³Orthopaedics, the First Affiliated Hospital, Sun Yat-sen University, Guangzhou, China, ⁴Medicine, Helsinki University Central Hospital, FI-00029 HUS, Helsinki, Finland
Correspondence ML: matti.lehto@coxa.fi
Submitted 05-03-31. Accepted 05-10-20

Background As revision total knee arthroplasty surgery is becoming more common, it is necessary to evaluate how individual revision prosthesis systems perform in degenerative and inflammatory arthritides. In this study, results of the use of the Total Condylar III (TC III) system in osteoarthritis (55 knees) were compared to results of its use in inflammatory arthritis (16).

Methods Patients were followed radiographically for 5.9 (3.0–10.2) years and clinically for 3.0 (0.2–6.8) years, using re-revision as the endpoint.

Results At 1 year after revision and at final follow-up, the total Knee Society knee score, function score and range of motion had improved (p < 0.001) with no differences between osteoarthritis and inflammatory arthritis. No knee had definite component loosening, although 23 knees had asymptomatic radiolucent lines. Complications comprised 4 infections, 1 patellar pain syndrome and 1 rupture of the patellar tendon. Using any re-revision of the prosthesis as the endpoint, 5-year survival was 95% and 8-year survival was 94%.

Interpretation Concentration of demanding revision knee arthroplasties to a few hands led to good or excellent knee joint knee score results in four-fifths of the patients, and showed good outcome with the TCIII system. In spite of ligamentous laxity, propensity to develop infections, bone destruction and poor general health, patients with inflammatory arthritis had results similar to those with osteoarthritis.

As the number of knee replacements performed each year continues to increase, and the cumulative number of patients who have a replaced knee concomitantly continues to grow, the number of patients undergoing revision surgery also increases.

The Total Condylar III system (TC III; Johnson and Johnson, Braintree, MA) was designed in 1977 to address the problem of severely deformed knees with ligamentous laxity, which is a challenge for the surgeon in the revision setting (Kim 1987, Donaldson et al. 1988). The use of the TC III prosthesis system in revision total knee arthroplasty has been reported by several authors (Kim 1987, Donaldson et al. 1988, Bush-Joseph et al. 1989, Rand 1991, Rosenberg et al. 1991). Its use in the treatment of complex knees in revision surgery has generally provided satisfactory clinical results.

Elke et al. (1995) reported that after primary total knee arthroplasty, the outcome in patients with rheumatoid arthritis was worse than in patients with osteoarthritis. In contrast, Robertsson et al. (2001) reported no difference in the cumulative revision rate between patients with osteoarthritis and rheumatoid arthritis, based on a large primary total knee replacement material from the Swedish Knee Arthroplasty Register. To our knowledge, no reports comparing the outcome of revision total knee arthroplasty in inflammatory arthritis...
and osteoarthritis have been published before. We therefore compared the outcome in osteoarthritis (n = 55) with that in inflammatory arthritis (n = 16) for revision total knee arthroplasty performed using the TC III system. The hypothesis was that due to better bone stock, patients with osteoarthritis would have better overall results.

**Patients and methods**

**Patients**

The individual ID numbers of the Finnish citizens who had undergone revision total knee arthroplasty at Tampere University Hospital until the end of the year 2000 were collected from the patient database of the hospital. Preoperative, operative and follow-up data were collected prospectively and saved in a database specially designed for the follow-up of joint replacement operations (Lehto et al. 1999). In addition, structured follow-up forms of physiotherapists enabled the calculation of the Knee Society score with all its subscales. 71 revision total knee arthroplasties (two bilateral) had been performed in Tampere University Hospital on 69 patients using the TC III system between 1994 and 2000. 16 knees were affected by inflammatory arthritis and 55 by osteoarthritis. Inflammatory arthritis patients had rheumatoid arthritis (n = 12), juvenile chronic arthritis (n = 2), psoriatic arthritis (n = 1) or ankylosing spondylitis (n = 1). There were 56 knees in women and 15 knees in men, and patients had a mean age of 69 (36–85) years. No differences were observed between osteoarthritis and inflammatory arthritis regarding sex (p = 0.8, Chi-square test) or follow-up time (p = 0.6, t-test), but there was a difference in age, with the OA patients being older than the inflammatory arthritis patients (p < 0.001, t-test). The date of the primary total knee arthroplasty, remarkable angular deformity (> 11° valgus or varus) was present in 9 knees and a milder deformity in 31 knees. The tibiofemoral angle was neutral in 32 knees. Severe anteroposterior instability was observed in 12 knees and severe mediolateral instability was seen in 21 knees. 12 knees were stable in both directions.

2 experienced senior orthopedic surgeons (JP and PH) performed all revision operations except 2 (in which the Larsen’s grade had not been recorded). With one exception, in all operations stemmed TC III components were used and fixed with antibiotic-impregnated bone cement (Palacos cum gentamycin). In 1 of the cases revised for infection, tobramycin was also added to this cement. 7 of the eight revisions performed for infections were done in two phases. Patella was re-surfaced in 35 cases. Systematic cefuroxime was used as prophylaxis.
Clinical and radiographic follow-up

Patients were examined before revision, during the hospitalization and at the outpatient clinic 2 months postoperatively, with further follow-up visits scheduled for 1, 3, 5 and 8 years after operation. All examinations included clinical and radiographic evaluation according to the prevailing routine follow-up regime. For clinical assessment, we used the Knee Society Clinical Rating System (Insall et al. 1989). Knee joint knee scores of 85–100 were considered excellent, 85–70 points good, 69–60 points fair, and less than 60 points poor. Anteroposterior and lateral radiographs of the knee were taken with the patient standing and evaluated using the Knee Society Rating System (Ewald 1989). The bone defects in the femoral and tibial side were classified according to the Anderson Orthopaedic Research Institute (AORI) bone defect classification guidelines (Gerard 1999) with 3 belonging to class T2a, 2 to T2b, 2 to T1, 1 F1T1 and 1 to class F1. Re-revision, arthrodesis, amputation or the death of the patient were used as endpoints. All patients were followed radiographically for 6 (3–10) years. The length of the clinical follow-up was 3 (0.2–6.8) years, as many patients without clinical problems were just evaluated radiographically.

Statistics

We used the Kaplan-Meier analysis for survivorship analysis. For comparison of the pre- and postoperative data and of different groups, we used t-test and Chi-Square test with the level of statistical significance being set at p < 0.05. Data were analyzed using SPSS version 11.0.

Results

Clinical results

One year after the revision operation and at the final follow-up visit, improvements were observed in the Knee Society knee score, function score, range of motion, pain score, walking score and stair climbing score compared to the preoperative state before the revision (p < 0.001 for all, t-test) (Table 1). 58/71 (0.8) cases had excellent or good outcome (44 excellent and 14 good). 3 cases had fair outcome and 9 cases had a poor outcome (Tables 2 and 3).
Results of radiography

The tibiofemoral angle (p = 0.04) and posterior slope of the tibial tray 8 (p = 0.05) improved from the preoperative state to the end of the follow-up. In the lateral view, the femoral component was in 5° (SD 7) of flexion preoperatively and in 3° (SD 2) of flexion postoperatively with respect to the femur (p = 0.02, t-test) (Table 1). Except for the posterior slope of the tibial tray and the distance from the center of the tibial component to the center of the tibia in the anteroposterior view, there were no differences between inflammatory arthritis and osteoarthritis (Table 3).

At the tibial or femoral bone-to-cement interfaces, radiolucent lines were seen in 23 of 71 knees (0.3) at the follow-up. 13 knees had radiolucent lines associated with both femoral and tibial components, 9 knees only with the tibial component and 1 knee only with the femoral component. At the femoral bone-to-cement interface, radiolucent lines were mainly seen in zone 1 (four-fifths of all such lines). At the tibial side, the radiolucent lines were seen mainly in zone 1 (two-fifths) and/or 4 (two-fifths of all such lines). The radiolucent lines were thicker than 2 mm (grade III) in only 5 cases, and in 3 more cases grade II 1–2 mm radiolucent lines were seen at the tibial bone-cement interface. Otherwise, all radiolucent lines were < 1 mm and represented grade I. Interestingly, none of the patients with inflammatory arthritis had grade II or III radiolucent lines. All 10 patients in whom allograft bone was used had excellent results, with no evidence of resorption, migration or loosening of the components.

Complications

By the end of August 2003, 3 of the 71 implanted prostheses had been removed—all due to infections. In a woman suffering from hypothyroidism and juvenile chronic arthritis treated with methotrexate and prednisolone, the patellar component loosened and caused fistula formation. The patellar component was removed 6 months after the index operation. A year later the whole prosthesis, infected with Staphylococcus aureus and Pseudomonas aeruginosa, was removed and the joint was debrided. A hinged knee prosthesis was implanted later and has functioned well since then. Another infected prosthesis was removed from another woman after 5 years. Her primary knee replacement was performed for osteoarthritis and she had also had a previous two-stage revision procedure for infected knee replacement. After the removal of the infected prosthesis and long-term anti-

Table 2. Overall clinical results of TC III knee revision surgery in osteoarthritis compared to those in inflammatory arthritis. Based on the knee score values of the Knee Society Clinical Rating System (Insall et al. 1989)

| Result   | Total | Osteoarthritis | Inflammatory arthritis | Chi-square test p > 0.05 |
|----------|-------|----------------|------------------------|--------------------------|
| Excellent| 44    | 33             | 11                     |                          |
| Good     | 14    | 11             | 3                      |                          |
| Fair     | 3     | 1              | 2                      |                          |
| Poor     | 9     | 9              | 0                      |                          |
| Total    | 70 a  | 54             | 16                     |                          |

a Clinical data were missing in one case.

Table 3. Comparison of the clinical and radiological outcome after TC III total knee replacement surgery in osteoarthritis and inflammatory arthritis. Values are mean (SD)

|                        | Osteoarthritis | Inflammatory arthritis | P-value |
|------------------------|----------------|------------------------|---------|
| Gender (men/women), n  | 12/43          | 3/13                   | 0.8     |
| Age (year)             | 72 (7)         | 59 (13)                | <0.001  |
| Follow-up time (year)  | 5.8 (1.5)      | 6.1 (2.0)              | 0.6     |
| Knee scores            | 82 (17)        | 88 (12)                | 0.2     |
| Function score         | 47 (31)        | 34 (35)                | 0.1     |
| Range of motion        | 100° (24)      | 96° (32)               | 0.8     |
| Pain score             | 41 (14)        | 44 (11)                | 0.5     |
| Walking score          | 27 (11)        | 22 (12)                | 0.1     |
| Stair climbing score   | 29 (16)        | 24 (19)                | 0.3     |
| Tibio-femoral angle    | 6° (3)         | 6° (3)                 | 0.5     |
| Femoral angle          | 97° (2)        | 97° (2)                | 0.4     |
| Tibial angle           | 89° (2)        | 89° (2)                | 0.5     |
| Femoral stem-femur angle | 3° (2)   | 2° (2)                 | 0.2     |
| Tibial tray, posterior slope | 2° (2) | 0° (2)                 | 0.009   |
| Tibial tray, anterior tilt | 1° (2) | 1° (2)                 | 0.6     |
| Tibial tray shift (AP), mm | 1.5 (1.9) | 0.7 (1.3)              | 0.04    |
| Tibial tray shift (lateral), mm | 0.9 (1.2) | 1.3 (1.4)              | 0.2     |
otic treatment, she received a hinged knee prosthesis that has remained infection-free. The infection was caused by coagulase-negative staphylococci. The third failure was also due to infection (with Staphylococcus aureus), and occurred 5 years after the revision operation. This male patient suffered from diabetes, peripheral neuropathy and chronic ulceration of the lower limb. It was considered unlikely that the infection could be cured and a thigh amputation was done. His primary total knee replacement had been performed for osteoarthritis and he had also undergone one earlier revision operation.

Other complications which did not, however, require removal of the prosthesis or any of its components were a staphylococcal infection of the prosthesis treated successfully with long-lasting antibiotic therapy, severe patellar pain treated with resurfacing 1 year after the revision arthroplasty, and rupture of the patellar tendon not related to the revision operation.

There were no complications during the early postoperative period at our hospital and none of the patients was referred to our hospital because of such complications. We found no information in the patient records concerning eventual complications treated at another institution.

**Survival analysis (Figure 1)**

After we had ensured from the Finnish Arthroplasty Register that none of the patients, except for those 3 already mentioned above, had had re-revisions in any other hospital, the situation at August 31, 2003 was used in the survival analysis. Using any re-revision of the prosthesis as the endpoint, 5-year survival was 95% and 8-year survival was 94%. Using removal of the prosthesis as the endpoint of follow-up, the 5-year survival was 97% (CI 92–101) and the 8-year survival was 94% (CI 87–101). The number of patients available for analysis was 43, 20, 9 and 3 at 5, 6, 7 and 8 years, respectively. With any failure as the endpoint, the 5-year survival was 93% (CI 87–100) and the 8-year survival was 91% (CI 82–99). The number of patients available for analysis was 42, 19, 9, and 3 at 5, 6, 7 and 8 years, respectively.

**Discussion**

Many reports have described the results of complex primary and revision total knee arthroplasties using the TC III system (Insall and Dethmers 1982, Kim 1987, Donaldson et al. 1988, Jacobs et al. 1988, Bush-Joseph et al. 1989, Chotivichit et al. 1991, Hohl et al. 1991, Kavolus et al. 1991, Rand 1991, Rosenberg et al. 1991, Lachiewicz and Falatyn 1996, Peters et al. 1997, Mow and Wiedel 1998). Compared to these studies, ours is the largest when the number of knees is considered. In Rosenberg’s paper (1991), 15/36 of the revisions were due to sepsis, whereas in the other papers the main reasons for revision were instability or loosening. The most striking finding is that we reached excellent or good outcomes in 58/71 of the revision total knee arthroplasties with the TC III system, whereas complications occurred in only 4 patients. The consistent use of one total revision knee implant design, together with the concentration of these operations to only a few highly specialized revision surgeons, led to results that were superior to those obtained in a regular setting. In our unit, it was decided very early that these demanding operations should be performed by only 2 surgeons. The 5- and 10-year survival rates were high when any re-revision or removal of the prosthesis was used as endpoint. These high survival rates probably have two main explanations. The learning curve referred to above apparently enabled close to perfect restoration of the alignment, which relieves stresses at
the cement-to-bone interface. Recent reports have suggested that radiolucent lines occur in one-third to three-quarters of cases after revision total knee arthroplasty using other prosthetic designs (Insall and Dethmers 1982, Jacobs et al. 1988, Takahashi and Gustilo 1994, Peters et al. 1997, Mow and Wiedel 1998). In our study, only 23 of 71 knees had radiolucent lines, all of them asymptomatic. It is noticeable that all more severe grade II and III radiolucent lines occurred in osteoarthritis, and none in rheumatoid arthritis. This may indicate that patients with rheumatoid arthritis do not, or are not able to, subject their joints to as heavy use as those with osteoarthritis. This may contribute to similar results in these two forms of arthritis in spite of the fact that the initial local joint status and general health status are worse in inflammatory rheumatoid arthritis than in “degenerative” osteoarthritis. We believe that the third-generation cementing technique also contributes to good implant fixation and long-term results compared to those published in previous reports (Kim 1987, Donaldson et al. 1988, Bush-Joseph et al. 1989, Rand et al. 1991, Rosenberg et al. 1991), where there was no indication of the use of modern cementing technique.

Inflammatory arthritis is often associated with cartilage and bone destruction and ligamentous laxity, incompetence and rupture (Ranawat et al. 1984, Stern et al. 1991, 2001, Peters et al. 2001). In addition, the bone stock is impaired by the juxta-articular and generalized osteoporotic changes caused by the disease and its treatment with corticosteroids (Westhovens and Dequeker 2000, Strand and Kavanaugh 2004). The unlinked, semiconstrained TC III system—provided with an enlarged tibial spine in conjunction with a deep femoral well—is specially designed to restore the joint stability and to prevent pathological movement of the prosthetized joint. In this respect, the TC III design apparently puts arthritis patients in line as those suffering from osteoarthritis. Cement fixation of non-modular stems, correct alignment and modest physical demands contribute to a long life in service. These features probably explain why results for inflammatory arthritis were as good as those for osteoarthritis. In general, arthritis patients have increased infection rates due to immunosuppressive medication, extraarticular complications and local joint damage compared to otherwise healthy patients. Only 1 of the 4 patients with an infection in this series had an underlying inflammatory arthritis.

In summary, our results demonstrate that in experienced hands the TC III system performs very well in revision total knee surgery. The unlinked, semi-constrained design allows attainment of excellent or good clinical results together with high medium-term survival rates, if the components are adequately positioned and cemented. Results can apparently be much improved by factors unrelated to the TC III system itself (which has good potential), such as earmarking TC III revision operations to be performed by specialized revision surgeons, together with the use of third-generation cementing techniques.

**Contributions of authors**
P-YS design of the radiological CRFs, radiographical analysis, statistical analysis, preparation of the manuscript, literature analysis. EJ design of the clinical CRFs, evaluation of the patients files, preparation of the manuscript, statistical analysis. MT development of the idea, seeking permit from the ethical committee and hospital, supervision of the work, organizing of the funding, coordination of activities, literature analysis, preparation of the manuscript. JP and PH all

### Table 4. Results of TCIII in revision total knee arthroplasty according to the literature

| Number of knees | Main reasons for the revision | Rating system | Excellent or good | Complication rate | Follow-up time (years) |
|----------------|-------------------------------|---------------|------------------|-------------------|------------------------|
| Kim et al. 1987 | 14 Loosening                   | HSS           | –                | 2/14              | 4.2                    |
| Donaldson et al. 1988 | 14 Ligament loss, deformities, instability | HSS   | 7/14             | 4/14              | 2.5–8                  |
| Rand et al. 1991 | 21 Bone loss, instability     | HSS           | 10/21            | 7/21              | 4                      |
| Rosenberg et al. 1991 | 36 Sepsis, loosening or instability | HSS   | 25/36            | 12/36             | 3.75                   |
| This study      | 71 Instability                 | KSS           | 58/71            | 6/71              | 4.2                    |

HSS: the Hospital for Special Surgery knee score; KSS: Knee Society knee score.
surgery and clinicians’ contribution to the manuscript. YTK development of the idea, supervision of the work, preparation of the manuscript, research management, contacts with the National Agency of Medicines, literature analysis.

No competing interests declared.

Bush-Joseph C A, Rosenberg A G, Barden R, Galante J O, Sheinkop M B. Total condylar III knee arthroplasty. Orthop Trans 1989; 13: 630.

Chotivichit A L, Cracchiolo A 3rd, Chow G H, Dorey F. Total knee arthroplasty using the total condylar III knee prosthesis. J Arthroplasty 1991; 6: 341-50.

Donadson W F, Sculco T P, Insall J N, Ranawat C S. Total condylar III knee prosthesis. Long-term follow-up study. Clin Orthop 1988; (226): 21-8.

Elke R, Meier G, Warnke K, Morschner E. Outcome analysis of total knee-replacements in patients with rheumatoid arthritis versus osteoarthritis. Arch Orthop Trauma Surg 1995; 114: 330-4.

Ewald F C. The Knee Society total knee arthroplasty roentgenographic evaluation and scoring system. Clin Orthop 1989; 248: 9-12.

Gerard A. Bone loss with revision total knee arthroplasty: defect classification and alternative for reconstruction. Instr Course Lect 1999; 48: 167-75.

Hohl W M, Crawford E, Zelicof S B, Ewald F C. The Total Condylar III prosthesis in complex knee reconstruction. Clin Orthop 1991; (273): 91-7.

Insall J N, Dethmers D A. Revision of total knee arthroplasty. Clin Orthop 1982; (170): 123-30.

Insall J N, Dorr L D, Scott R D, Scott W N. Rationale of the Knee Society clinical rating system. Clin Orthop 1989; (248): 13-4.

Jacobs M A, Hungerford D S, Krackow K A, Lennox D W. Revision total knee arthroplasty for aseptic failure. Clin Orthop 1988; (226): 78-85.

Kavolus C H, Faris P M, Ritter M A, Keating E M. The total condylar III knee prosthesis in elderly patients. J Arthroplasty 1991; 6: 39-43.

Kim Y H. Salvage of a failed hinge knee arthroplasty with a Total Condylar III type prosthesis. Clin Orthop 1987; (221): 272-7.

Lachiewicz P F, Falatyn S P. Clinical and radiographic results of the Total Condylar III and Constrained Condylar total knee arthroplasty. J Arthroplasty 1996; 11: 916-22.

Larsen A, Dale K, Eek M. Radiographic evaluation of rheumatoid arthritis and related conditions by standard reference films. Acta Radiol Diagn 1977; 18: 481-91.

Lehto M U K, Halonen P, Pajamäki J, Tarvainen T, Halonen P, Moilanen T, Nomminen O, Nevalainen J, Välimäki A. Teknoniveltkurgian (TEKO) seurannan (SE) tietokanta (T) – TEKOSET: mahdollisuus kansalliseen seurantajärjestelmään. (In Finnish) J Finnish Orthop Assoc 1999; 22: 92-9.

Mow C S, Wiedel J D. Revision total knee arthroplasty using the porous-coated anatomic revision prosthesis. J Arthroplasty 1998; 13: 681-6.

Nevalainen J. The 2002-2003 implant year book on orthopaedic endoprostheses. Finnish Arthroplasty Register. 136 p. (available at http://www.nam.fi/uploads/julkaisut/Orthopaedic Endoprostheses 2003 v.PDF).

Peters C L, Hennessy R, Barden R M, Galante J O, Rosenberg A G. Revision total knee arthroplasty with cemented posterior-stabilized or constrained condylar prosthesis. J Arthroplasty 1997; 12: 896-903.

Peters C L, Mohr R A, Bachus K N. Primary total knee arthroplasty in the valgus knee: creating a balanced soft tissue envelope. J Arthroplasty 2001; 16: 721-9.

Ranawat C S, Rose H A, Rich D S. Total condylar knee arthroplasty for valgus and combined valgus-flexion deformity of the knee. Instr Course Lect 1984; 33: 412-6.

Rand J A. Revision total knee arthroplasty using the total condylar III prosthesis. J Arthroplasty 1991; 6: 279-84.

Robertson O, Knutson K, Lewold S, Lidgren L. The Swedish Knee Arthroplasty Register 1975-1997: an update with special emphasis on 41,223 knees operated on in 1988-1997. Acta Orthop Scand 2001; 72: 503-13.

Rosenberg A G, Verner J J, Galante J O. Clinical results of total knee revision using the Total Condylar III prosthesis. Clin Orthop 1991; (273): 83-90.

Stern S H, Moeckel B H, Insall J N. Total knee arthroplasty in valgus knees. Clin Orthop 1991; (273): 5-8.

Stern S H, Insall J N. Total knee arthroplasty with posterior cruciate ligament substitution designs. In: Surgery of the knee (eds. Insall J N, Scott W N). Churchill Livingstone 2001: 1660-94.

Strand V, Kavanaugh A F. The role of interleukin-1 in bone resorption in rheumatoid arthritis. Rheumatology (Oxford) (Suppl 3) 2004; 43: iii10-iii16.

Takahashi Y, Gustilo R B. Nonconstrained implants in revision total knee arthroplasty. Clin Orthop 1994; (309): 156-62.

Westhovens R, Dequeker J. Rheumatoid arthritis and osteoporosis. J Rheumatol (Suppl 1) 2000; 59: 33-8.