Revision total knee arthroplasty with the Total Condylar III system

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

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As the number of knee replacements performed each year increases, and the accumulative number of patients who have had a knee replacement also increases, the number of patients undergoing revision surgery is increasing. The Total Condylar III system (TC III; Johnson and Johnson, Brunswick, NJ) was developed 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 in revision total knee arthroplasty has been reported by several authors (Kim 1987, Donaldson et al. 1988, Rush-Cooper et al. 1989, Rand 1991, Rosenberg et al. 1995). Its use in the treatment of complex knee revision surgery has generally provided satisfactory clinical results. Ekeland 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, Rorabeck et al. (2000) reported no difference in the outcome 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

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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 and the type of the implanted prosthesis were confirmed from the Finnish Arthroplasty Register maintained by the Finnish National Agency of Medicines (Nevalainen 2003). We also made sure from the National Arthroplasty Register that none of the patients in the current series had had any re-revision arthroplasties in hospitals other than Tampere University Hospital or Coxa Hospital for Joint Replacement. Revision was defined as any new operation during which one or more of the components are exchanged, removed or added (including arthrodesis or amputation).

In inflammatory arthritis, preoperatively, Larsen's grade (Larsen et al. 1977) for radiographic knee destruction was III in 3 cases, IV in 5 cases, V in 6 cases and unknown in 2 cases. The time interval between the primary and revision arthroplasty was 6.8 years on average. In some patients, two or more reasons were recorded for the revision operation and they were as follows: instability (n = 41), polyethylene wear (n = 26), osteolysis (n = 21), aseptic loosening (n = 17), malposition (n = 8), patellar dislocation and/or severe subluxation (n = 8), periprosthetic bone fracture (n = 5), infection (n = 4), knee dislocation (n = 3), or fracture of a prosthetic component (n = 1). All removed prostheses were tri-compartmental, viz. AGC (n = 9), Anametric (n = 1), Duracon (n = 11), Miller-Galante (n = 2), PFC (CR) (n = 2), PFC TC3 (n = 1), PCA (n = 9), PCA Modular (n = 16), Townley Synatomic (n = 15), and Townley (n = 5). All removed prostheses were cruciate-retaining condylar total knee implants except for 1 PFC TCIII, which was infected. Thus, the series comprised 25 cases with PCA or PCA modular and 20 cases with Townley or Townley Synatomic. 2 cases were treated using wedges and 10 cases with structural bone allograft, 8 for bone defects and 2 to restore alignment. 2 of the structural bone allografts were used in inflammatory arthritis patients and 8 in osteoarthritis patients.

Before revision 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.

Table 1. Clinical and radiographic results of the TC III-operated patients before the operation compared to the situation after 1 year and at the final follow-up visit. Figures are mean (SD)

	Preoperatively	1 year follow-up	P-value preop. vs 1 year FU	Final follow-up	P-value preop. vs final FU
Knee score	44 (19)	89 (13)	< 0.0001	84 (16)	< 0.0001
Function score	30 (24)	53 (27)	< 0.0001	44 (31)	< 0.0001
Range of motion	78° (42)	102° (21)	< 0.0001)	100° (26)	< 0.0001
Pain score	24 (13)	46 (9)	< 0.0001	42 (13)	< 0.0001
Walking score	19 (8)	29 (8)	< 0.0001	27 (11)	< 0.0001
Stair climbing score	19 (15)	32 (13)	< 0.0001	29 (16)	< 0.0001
Tibiofemoral angle	2° (5)	6° (3)	0.004	6° (3)	< 0.0001
Femoral angle	96° (3)	97° (2)	0.7	96° (2)	0.8
Tibial angle	87° (5)	89° (2)	0.008	89° (2)	0.001
Femoral stem-femur angle	5° (7)	3° (2)	0.02	3° (2)	0.03
Tibial tray, posterior slope	5° (7)	2° (3)	0.005	2° (2)	0.001
Tibial tray, anterior tilt	3° (5)	1° (2)	0.007	1° (2)	< 0.0001
Tibial tray shift (AP) in mm	1.8 (1.9)	1.2 (1.5)	0.1	1.2 (1.6)	0.06
Tibial tray shift (lateral) in mm	1.2 (2.1)	1.1 (1.4)	0.7	0.8 (1.1)	0.2

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 (Table 2). No statistically significant differences were observed between inflammatory arthritis and osteoarthritis, although the results obtained in osteoarthritis showed a slight trend toward a better outcome (Tables 2 and 3).

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

[a] Clinical data were missing in one case.

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) at the femoral and/or tibial bone-cement interfaces 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 arthritides 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.

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)

	Osteo-arthritis	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)	98° (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

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 antibi-

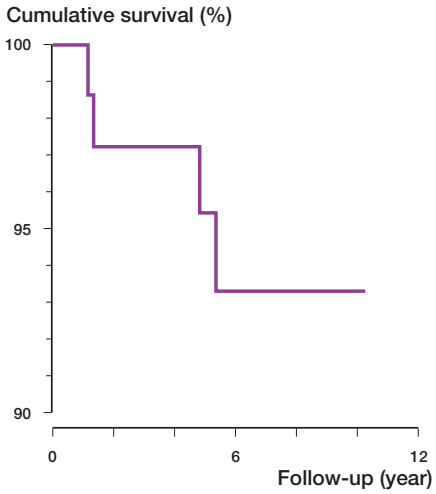

Figure 1. Kaplan Meier Survival curve for TC III knee arthroplasty using any re-revision as the endpoint.

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

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.

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 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

surgery and clinicians' contribution to the manuscript. YTK development of the idea, supervision of the work, preparation of the manuscript, research management, contacts wit the National Agency of Medicines, literature analysis.

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