Early patient outcomes after primary and revision total knee arthroplasty

A PROSPECTIVE STUDY

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There has been speculation as to how the outcome of revision total knee arthroplasty (TKA) compares with that of primary TKA. We have collected data prospectively from patients operated on by one surgeon using one prosthesis in each group. One hundred patients underwent primary TKA and 60 revision TKA. They completed SF-12 and WOMAC questionnaires before and at six and 12 months after operation.

The improvements in the SF-12 physical scores and WOMAC pain, stiffness and function scores in both primary and revision TKA patients were highly statistically significant at six months. There was no statistically significant difference in the size of the improvement in the SF-12 physical and WOMAC pain, stiffness and function scores between the primary and revision patients at six months after surgery. The SF-12 mental scores of patients in both groups showed no statistically significant difference after surgery at the six- and 12-month assessments.

Our findings show that primary and revision TKA lead to a comparable improvement in patient-perceived outcomes of physical variables in both generic and disease-specific health measures at follow-up at one year.

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There has been speculation as to how the outcome of revision total knee arthroplasty (TKA) compares with that of primary TKA. The former is technically demanding and the rates of satisfactory results have not been as high as

those after primary TKA, varying between 37% and 89%.¹⁻³⁰ Many of the series were retrospective, included small numbers of patients and involved numerous surgeons using a variety of prostheses in different hospitals. In this study we have assessed prospectively the outcome of revision and primary TKA performed by a single surgeon, in one hospital, using a single design of implant in each group. The outcome measures which we used were the generic short-form health questionnaire (SF-12)³¹ and the disease-specific Western Ontario and McMasters osteoarthritis index (WOMAC).^{32,33}

The primary prosthesis was a modular, cruciate-retaining implant. The femoral component was porous-coated and uncemented. The tibial component was cemented and the patella was resurfaced with a cemented polyethylene button. The revision implant used a fluted, canal-filling, cementless stem to obtain a press-fit with augments and/or wedges to address bony deficiency. The stem was 95 mm long in most cases. Occasionally, we used a short tapered stem if the bone stock was good or a 140 mm canal-filling stem if there was major osteolysis. The patella was resurfaced whenever possible. If the bone stock was poor or the patella too thin it was not resurfaced. The housing of both femoral and tibial components was cemented in all cases. The insert used was either posterior-stabilised or varus-valgus-constrained (Fig. 1).

The revision TKAs were performed for failure of the primary Accord implant (Thackray, Leeds, UK) (Fig. 2). The causes of failure included aseptic loosening, wear of polyethylene, meniscal subluxation and instability, malalignment and patellofemoral maltracking.

Patients and Methods

We included in the study all patients undergoing revision TKA between 1997 and 2000 and 100 consecutive patients undergoing primary TKA between 1997 and 1999, in 85 for osteoarthritis and in 15 for rheumatoid arthritis. In the revision group there were 35 women and 25 men with a mean age at surgery of 75 years (57 to 88) and in the primary group 54 women and 46 men with a mean age of 76 years (47 to 90).

All the operations were performed by the senior author (RWP). The prosthesis used in the primary TKA was the

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Fig. 1a

Fig. 1b

Fig. 1c

Radiographs showing a) anteroposterior, b) lateral and c) skyline views of the Co-Ordinate revision TKA with canal-filling inserts on the femoral and tibial components.

Fig. 2a

Fig. 2b

Fig. 2c

Radiographs showing a) anteroposterior (AP), b) lateral and c) skyline views of the Accord TKA. There is a loose, extended femoral component, patellar maltracking and patella baja. Osteolysis is present in the lateral femoral condyle with a 'crescent sign' on the AP view.

Anatomic Modular Knee (AMK-DePuy, Warsaw, Indiana). The Co-Ordinate prosthesis (DePuy) was used for revision surgery until 1999 and the Co-Ordinate Ultra prosthesis (DePuy) thereafter. The latter had screw-on stems as opposed to the taper-fit stems of the Co-Ordinate prosthesis.

All the patients were interviewed and completed the SF-12 and WOMAC questionnaires before and at six and 12 months after operation.

The SF-12 generic health status questionnaire is derived from the SF-36 questionnaire.³¹ It is used to assess overall health status and measures two components, physical health (physical component summary scale - PCS) and mental

health (mental component summary scale - MCS). It is a reliable and validated outcome measure.

The disease-specific WOMAC questionnaire is also a reliable and validated outcome measure. It was developed to assess outcomes in studies of osteoarthritis of the hip and knee^{32,33} and consists of three areas: pain (five items), stiffness (two items) and function (17 items). The total score is obtained by summing the individual scores, but the individual scores allow assessment of changes in the separate variables. The responses were entered into a database. The SF-12 PCS and MCS health summary scales were calculated using the SF-12 interpretation manual³⁴ and changes in the WOMAC score were determined.

Statistical analysis. We used the SPSS statistical software package (SPSS Inc, Chicago, Illinois). For between-group comparisons (primary *versus* revision TKA) a two-way hierarchical repeated measures analysis of variance (ANOVA) was performed and for within-group comparisons (primary and revision separately) a simple repeated-measures ANOVA. Only if the results of the latter were significant were paired *t*-tests performed to compare pairs of times using a Bonferroni *post-hoc* adjustment to the *p* value to avoid spurious results. Since the changes in the mean scores from before operation to 6 and to 12 months after operation are of interest, a two-way hierarchical repeated-measures ANOVA was used for between-group comparisons. The within-group comparisons of the change in score either preoperative to 6 months or preoperative to 12 months were evaluated using a paired *t*-test.

Preliminary analysis of the data showed that the mean scores and changes in scores over time had a normal distribution. A *p* value < 0.05 was taken to be significant.

Results

WOMAC scores. Table I gives the mean scores and the mean changes in scores with 95% confidence intervals. There was no significant difference in the preoperative score between the two groups using an unpaired *t*-test (pain, *p* = 0.697; stiffness, *p* = 0.978; function, *p* = 0.779).

Two-way hierarchical repeated-measures ANOVA of the mean scores showed that they were significantly different over time in both groups (*p* < 0.001). When applied to the change in score there was no significant difference in the magnitude of the changes in pain, stiffness and function scores between the preoperative and 6-month and between the preoperative and 12-month assessments (ANOVA *F* values for pain change = 0.029, *p* = 0.864; for stiffness change = 1.543, *p* = 0.216; for function change = 0.764, *p* = 0.383). Comparison between the two groups showed that the revision patients had significantly higher pain and

Table I. Mean scores with mean changes in score, 95% confidence intervals and *post-hoc* adjusted Bonferroni *t*-test results of pairs of times after simple repeated-measures ANOVA

	Primary Mean (95% CI)	<i>p</i> value*	Revision Mean (95% CI)	<i>p</i> value*
Pain				
Preop	16.3 (15.7 to 16.8)		16.2 (15.3 to 17.2)	
6 mths	7.8 (7.1 to 8.6)		9.2 (8.2 to 10.2)	
12 mths	6.7 (6.1 to 7.4)		10.2 (9.2 to 11.1)	
Change preop to 6 mths	-8.5 (-9.4 to -7.4)	< 0.001	-7.0 (-8.2 to -5.9)	< 0.001
Change 6 to 12 mths	-1.1 (-2.1 to -0.2)	0.026	1.0 (-0.3 to 2.2)	0.117
Change preop to 12 mths	-9.6 (-10.4 to -8.7)	< 0.001	-6.0 (-7.5 to -4.6)	< 0.001
Stiffness				
Preop	6.4 (6.0 to 6.7)		6.5 (5.9 to 7.0)	
6 mths	4.0 (3.7 to 4.4)		4.6 (4.2 to 5.0)	
12 mths	3.6 (3.3 to 3.9)		4.5 (4.1 to 4.9)	
Change preop to 6 mths	-2.4 (-2.8 to -1.9)	<0.001	-1.9 (-2.6 to -1.2)	< 0.001
Change 6 to 12 mths	-0.4 (-0.9 to 0.1)	0.139	-0.1 (-0.7 to 0.5)	0.69
Change preop to 12 mths	-2.8 (-3.3 to -2.2)	< 0.001	-2.0 (-2.7 to -1.3)	< 0.001
Function				
Preop	53.7 (51.4 to 56.0)		53.2 (49.8 to 56.5)	
6 mths	29.9 (27.2 to 32.7)		34.0 (30.9 to 37.1)	
12 mths	24.7 (22.6 to 26.8)		37.0 (33.8 to 40.3)	
Change preop to 6 mths	-23.8 (-26.7 to -20.7)	< 0.001	-19.2 (-23.6 to -14.7)	< 0.001
Change 6 to 12 mths	-5.2 (-8.5 to -2.0)	0.002	3.0 (-0.9 to 6.8)	0.124
Change preop to 12 mths	-29.0 (-31.9 to -26.0)	< 0.001	-16.2 (-21.5 to -10.8)	< 0.001
PCS				
Preop	34.3 (32.5 to 36.1)		29.7 (27.5 to 31.9)	
6 mths	40.8 (39.0 to 42.6)		36.7 (33.9 to 39.4)	
12 mths	41.1 (38.6 to 43.7)		34.9 (31.8 to 37.9)	
Change preop to 6 mths	6.5 (4.5 to 8.6)	<0.001	7.0 (3.6 to 10.3)	0.001
Change 6 to 12 mths	0.3 (-2.8 to 3.5)	0.838	-1.8 (-5.3 to 1.7)	0.313
Change preop to 12 mths	6.8 (3.8 to 9.9)	< 0.001	5.2 (1.4 to 8.9)	0.009
MCS				
Preop	52.2 (49.9 to 54.6)		52.7 (49.7 to 55.7)	
6 mths	52.1 (50.1 to 54.0)		54.4 (52.0 to 56.7)	
12 mths	53.3 (51.4 to 55.2)		52.8 (50.3 to 55.4)	
Change preop to 6 mths	-0.1 (-3.2 to 2.8)		1.7 (-2.5 to 5.8)	
Change 6 to 12 mths	1.2 (-1.4 to 3.8)		-1.6 (-5.3 to 2.2)	
Change preop to 12 mths	1.1 (-1.9 to 4.1)		0.1 (-3.3 to 3.3)	

**post-hoc* Bonferroni *t*-test

function scores ($p < 0.001$) but not stiffness scores ($p = 0.168$). The improvements in the pain, stiffness and function scores over time were statistically significant in both groups (ANOVA F values for primary pain = 545.6, stiffness = 112.9, function = 376.8, $p < 0.001$; for revision pain = 69.8, stiffness = 35.7, function = 36.7, $p < 0.001$).

In the primary group, only pain and function scores improved significantly between 6 and 12 months ($p = 0.026$ and $p = 0.002$, respectively). There was no significant improvement in any of the scores in the revision group between 6 and 12 months. The changes in pain and function scores in the primary group were significantly greater than those in the revision group between 6 and 12 months (pain $F = 20.160$, $p = 0.009$ and function $F = 20.714$, $p < 0.001$).

Comparison of the magnitude of the changes in scores from the preoperative to the 6-month assessment, using unpaired t -tests, revealed no significant differences between the two groups (pain $p = 0.056$, stiffness $p = 0.208$, function $p = 0.079$). Comparison of the changes in scores within the two groups using paired t -tests showed that the magnitude of change in pain, stiffness and function scores was greater in the preoperative to 6-month period than in the 6- to 12-month period (Table II).

SF-12 scores

PCS. Table I gives the mean scores and the mean changes in scores with 95% confidence intervals. Two-way hierarchical repeated-measures ANOVA of the scores showed that they were significantly different over time in both

groups ($p < 0.001$) but not between groups ($p = 0.618$). The preoperative PCS score was significantly higher in the primary group than in the revision group using an unpaired t -test ($p = 0.012$). In both groups there were statistically significant improvements in the PCS score with time on analysis by a simple repeated-measures ANOVA (primary $F = 19.6$, $p < 0.001$, revision $F = 7.4$, $p = 0.008$). Bonferroni *post-hoc* adjusted t -tests on pairs of times showed significant changes between the preoperative and 6-month assessment (primary $p < 0.001$, revision $p < 0.001$) and the preoperative and 12-month assessment (primary $p < 0.001$, revision $p < 0.001$). There was no significant change in score in either group between 6 and 12 months (primary $p = 0.838$, revision $p = 0.313$).

Two-way hierarchical repeated-measures ANOVA of the changes in score between the preoperative and 6-month and preoperative and 12-month assessments for the between-group comparisons showed that there was no significant difference in the size of the changes in the PCS score between primary and revision patients ($F = 0.467$, $p = 0.495$) or between the preoperative and 6-month and preoperative and 12-month assessments ($F = 0.354$, $p = 0.553$). Comparison of the size of the changes in score from the preoperative to 6-month assessment, using unpaired t -tests, showed no significant differences between the two groups of patients ($p = 0.817$).

Comparison of the changes in scores within the two groups using paired t -tests showed that the size of the change in score is greater in the preoperative to 6-month period than in the 6- to 12-month period (primary $p = 0.006$ and revision $p = 0.004$) (Table II).

MCS. Analysis of the MCS scores using a two-way hierarchical repeated-measures ANOVA showed no significant difference between the two groups ($p = 0.489$) or with time ($p = 0.79$).

Table II. Results of paired t -test for comparison of changes of score within groups between the preoperative and 6-month assessment and the 6- and 12-month assessment with mean differences in change between the time periods, 95% confidence intervals and t values

	Primary	Revision
Pain change		
t value	8.9	8.4
p value	< 0.001	< 0.001
Mean difference	-7.4	-8.0
95% CI	-8.9 to -5.7	-9.9 to -6.1
Stiffness change		
t value	5.1	-3.3
p value	< 0.001	0.002
Mean difference	-2.0	-1.8
95% CI	-2.8 to -1.2	-2.9 to -0.7
Function change		
t value	-6.6	-6.9
p value	< 0.001	< 0.001
Mean difference	-18.6	-22.2
95% CI	-23.9 to -12.9	-28.5 to -15.8
PCS change		
t value	2.8	3.0
p value	0.006	0.004
Mean difference	6.2	8.8
95% CI	1.8 to 10.5	2.9 to 14.5
MCS change		
t value	-0.6	0.9
p value	0.556	0.370
Mean difference	-1.3	3.3
95% CI	-6.1 to 3.3	-3.9 to 10.4

Discussion

Revision TKA is a technically difficult procedure. Exposure can be difficult because of stiffness and adhesions. In addition, there is often instability due to ligamentous laxity and the bone stock may be poor. The results of revision surgery have not matched those of primary TKA.¹⁻³⁰ Our aim in this prospective study was to evaluate the results of revision TKA performed by one surgeon, using one prosthesis and compare them with those in a group of primary TKA patients operated on by the same surgeon using one prosthesis during the same time period. The revision TKAs were performed for failure of the primary Accord implant which was locally popular but not successful in terms of design and survivorship.

There have been many studies which have determined the effectiveness of TKA in reducing pain and deformity and improving function.³⁵⁻⁴¹ Most have assessed outcomes using standardised knee scoring systems such as the Hospital for Special Surgery (HSS) score or The

Knee Society score (KSS).^{38,41-47} These have not been validated and are surgeon-specific. They have poor internal reliability and small effect sizes and are therefore not good for assessing outcomes in TKA.⁴⁸ This casts doubt on the validity of the results of these studies. Several papers have specifically considered the outcomes in elderly patients.^{42,49,50}

The outcome measures which we have used (SF-12 and WOMAC) are reliable and validated scoring systems.^{31-33,48} To our knowledge, no study has been published which has prospectively assessed patient-perceived outcomes after revision TKA and compared them with primary TKA.

Anderson et al⁵¹ showed a significant correlation between the SF-36 score, the WOMAC pain and function scores and patient satisfaction. Those patients with better WOMAC function scores also had higher SF-36 physical scores, indicating a relationship between improved knee function and improved overall function. The HSS score did not correlate with patient satisfaction. Neither the HSS nor the KSS scores showed any correlation with the WOMAC pain score, the SF-36 bodily pain score or patient satisfaction.

Our findings show no significant difference in the preoperative WOMAC scores between the two groups. The revision patients, however, had worse preoperative PCS scores than the primary patients. This may be due to the fact that they already had had surgery on their knees using an unsuccessful implant.

We have also shown that the improvements in SF-12 PCS and WOMAC pain, stiffness and function scores in primary and revision TKA are highly statistically significant at the six-month assessment. There was no statistically significant difference in the size of the mean improvement from the preoperative to the six-month assessment between the primary and revision patients in SF-12 PCS scores and WOMAC pain, stiffness and function scores. This indicates that in terms of patient-perceived outcome measures, revision TKA leads to as great an improvement as does primary TKA. Both groups of patients showed a statistically significant improvement in WOMAC pain, stiffness and function scores and SF-12 PCS scores between the preoperative and 12-month assessments. There was no significant change in SF-12 MCS scores in either group over this period of time.

There was no significant change in SF-12 PCS scores in either group between 6 and 12 months. This indicated that the patients had reached an 'end-stage' in recovery of generic physical health status at six months. However, in the WOMAC pain and function areas, the primary patients continue to improve up to 12 months, whereas the revision patients did not improve significantly between the 6- and 12-month assessments.

The perception among knee surgeons is that a TKA will continue to improve up to 12 months after surgery. We have shown that this is true of the primary patients in terms of pain and function but not of revision patients. There is,

however, continued improvement in stiffness scores in the revision patients, but this was not statistically significant. This is not the case in terms of the SF-12 generic health measure, as both groups attain maximum improvements at six months after surgery. This may be because the WOMAC outcome measure is designed to be maximally sensitive in patients with knee symptoms as a result of osteoarthritis, whereas the SF-12 is intended to address a wide range of health problems and is therefore less specific.⁵² The mental scores of patients in both groups showed no statistically significant improvement after the operation. Also, there was no statistically significant difference in the mental scores before and after operation between the primary and revision groups. Thus, the commonly held perception that mental state and sense of well-being are improved after TKA is not true. This may be because patients' poor preoperative mental state reflects their type of personality rather than their physical problems. We aim to perform further research into this area by attempting to identify a correlation between high preoperative SF-12 mental scores and high postoperative SF-12 physical scores.

We conclude that revision TKA leads to a comparable improvement in both generic health outcome measures and disease-specific outcome measures as does primary TKA.

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References

1. **Ahlberg A, Lunden A.** Secondary operations after knee joint replacement. *Clin Orthop* 1981;156:170-4.
2. **Bargar WL, Cracchiolo AI, Amstutz HC.** Results of constrained total knee prosthesis in treating severely disabled patients and patients with failed total knee replacements. *J Bone Joint Surg [Am]* 1980;62-A:504-12.
3. **Bertin KC, Freeman MAR, Samuelson KM, Ratcliffe SS, Todd RC.** Stemmed revision arthroplasty for aseptic loosening of total knee replacement. *J Bone Joint Surg [Br]* 1985;67-B:242-8.
4. **Brady TA, Ranawat CS, Kettelkamp DB, Rapp GF.** Salvage of the failed total knee arthroplasty. *Orthop Trans* 1977;1:101-2.
5. **Bryan RS, Rand JA.** Revision total knee arthroplasty. *Clin Orthop* 1982;170:116-22.
6. **Cameron HU, Hunter GA.** Failure in total knee arthroplasty: mechanisms, revisions, and results. *Clin Orthop* 1982;170:141-6.
7. **Donaldson WF III, Sculco TP, Insall JN, Ranawat CS.** Total condylar III knee prosthesis: long-term follow-up study. *Clin Orthop* 1988;226:21-8.
8. **Dupont JA, Campbell ED Jr, Lumsden RM.** Total knee arthroplasty revisions. *Orthop Trans* 1980;4:321-2.
9. **Friedman RJ, Hirst P, Poss P, Kelley K, Sledge CB.** Results of revision total knee arthroplasty performed for aseptic loosening. *Clin Orthop* 1990;255:235-41.
10. **Goldberg VM, Figgie MP, Figgie HE, Sobel M.** The results of revision total knee arthroplasty. *Clin Orthop* 1988;226:86-92.
11. **Hanssen AD, Rand JA.** A comparison of primary and revision total knee arthroplasty using the Kinematic Stabilizer prosthesis. *J Bone Joint Surg [Am]* 1988;70-A:491-9.
12. **Hood RW, Insall JN.** Total knee revision arthroplasty: indications, surgical techniques and results. *Orthop Trans* 1981;5:412-3.
13. **Insall JN, Dethmers DA.** Revision of total knee arthroplasty. *Clin Orthop* 1982;170:123-30.

14. Insall JN, Lachiewicz PF, Burstein AH. The posterior stabilized condylar prosthesis: a modification of the total condylar design: two to four-year clinical experience. *J Bone Joint Surg [Am]* 1982;64-A:1317-23.
15. Jacobs MA, Hungerford DS, Krackow KA, Lennox DW. Revision total knee arthroplasty for aseptic failure. *Clin Orthop* 1988;226:78-85.
16. Kim L, Finerman G. Results of revision for aseptic failed knee arthroplasties. *Orthop Trans* 1983;7:535.
17. Lewis JL, Askew MJ, Jaycox DP. A comparative evaluation of tibial component designs of total knee prostheses. *J Bone Joint Surg [Am]* 1982;64-A:129-35.
18. Rand JA, Bryan RS. Revision after total knee arthroplasty. *Orthop Clin North Am* 1982;13:201-12.
19. Rand JA, Bryan RS. Results of revision total knee arthroplasties using condylar prostheses: a review of fifty knees. *J Bone Joint Surg [Am]* 1988;70-A:738-45.
20. Rand JA, Peterson LF, Bryan RS, Ilstrup DM. Revision total knee arthroplasty. *Instr Course Lect* 1986;35:305-18.
21. Ritter MA. The Herbert total knee replacement: a longer than three year follow-up. *Clin Orthop* 1977;129:232-5.
22. Scuderi GR, Insall JN, Windsor RE, Moran MC. Survivorship of cemented knee replacements. *J Bone Joint Surg [Br]* 1989;71-B:798-803.
23. Stern SH, Insall JN. Total knee arthroplasty in obese patients. *J Bone Joint Surg [Am]* 1990;72-A:1400-4.
24. Thornhill TS, Dalziel RW, Sledge CB. Alternatives to arthrodesis for the failed total knee arthroplasty. *Clin Orthop* 1982;170:131-40.
25. Thornhill TS, Hood RW, Dalziel RW, et al. Knee revision in failed non-infected total knee arthroplasty: the Robert B. Brigham Hospital and Hospital for Special Surgery experience. *Orthop Trans* 1982;6:368-9.
26. Vince KG, Long W. Press fit long stem revision total knee arthroplasty. Poster presentation. Annual Meeting of the Knee Society, New Orleans, Louisiana.
27. Walker PS, Greene D, Reilly D, et al. Fixation of tibial components of knee prostheses. *J Bone Joint Surg [Am]* 1981;63-A:258-67.
28. Wertzberger KL, Bryan RS. Analysis of failed total knee arthroplasty, excluding infection, undergoing reoperation. *Orthop Trans* 1979;3:265-6.
29. Wilde AH, Schickendantz MS, Stulberg BN, Go RT. The incorporation of tibial allografts in total knee arthroplasty. *J Bone Joint Surg [Am]* 1990;72-A:815-24.
30. Su DHC, Chan CW, Seow KH, et al. Results of revision total knee arthroplasty. *Singapore Med J* 2000;41:6-8.
31. Stewart AL, Hays RD, Ware JE Jr. The MOS short-form general health survey: reliability and validity in a patient population. *Med Care* 1988;26:724-35.
32. Bellamy N, Buchanan WW, Grace E. Double-blind randomized controlled trial of isoxicam vs piroxicam in elderly patients with osteoarthritis of the hip and knee. *Br J Clin Pharmacol* 1986;22 (Suppl 2):149S-55S.
33. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. *J Rheumatol* 1988;15:1833-40.
34. Ware JE Jr, Kosinski M, Keller S. SF-12: how to score the SF-12 physical and mental health summary scales. QualityMetric Incorporated, 1998.
35. Goldberg VM, Figgie MP, Figgie HE, Heiple KG, Sobel M. Use of a total condylar knee prosthesis for treatment of osteoarthritis and rheumatoid arthritis: long term results. *J Bone Joint Surg [Am]* 1988;70-A:802-11.
36. Hungerford DS, Krackow KA. Total joint arthroplasty of the knee. *Clin Orthop* 1985;192:23-33.
37. Insall JN, Scott WN, Ranawat CS. The total condylar knee prosthesis: a report of two hundred and twenty cases. *J Bone Joint Surg [Am]* 1979;61-A:173-80.
38. Insall JN, Hood RW, Flawn LB, Sullivan DJ. The total condylar knee prosthesis in gonarthrosis: a five to nine-year follow-up of the first one hundred consecutive replacements. *J Bone Joint Surg [Am]* 1983;65-A:619-28.
39. Murray DG. Total knee arthroplasty. *Clin Orthop* 1985;192:59-68.
40. Riley LH. Total knee arthroplasty. *Clin Orthop* 1985;192:34-9.
41. Stern SH, Bowen MK, Insall JN, Scuderi GR. Cemented total knee arthroplasty for gonarthrosis in patients 55 years old or younger. *Clin Orthop* 1990;260:124-9.
42. Cohn BT, Krackow KA, Hungerford DS, Lennox DW, Bachner EJ. Results of total knee arthroplasty in patients 80 years and older. *Orthop Rev* 1990;19:451-60.
43. Insall JN, Binazzi R, Soudry M, Mestriner LA. Total knee arthroplasty. *Clin Orthop* 1985;192:13-22.
44. Insall JN, Dorr LD, Scott RD, Scott WN. Rationale of the Knee Society clinical rating system. *Clin Orthop* 1989;248:13-4.
45. Ranawat CS, Flynn WF, Saddler S, Hansraj KK, Maynard MJ. Long term results of the total condylar knee arthroplasty: a 15-year survivorship study. *Clin Orthop* 1993;286:94-102.
46. Vince KG, Insall JN. Long term results of cemented total knee arthroplasty. *Orthop Clin North Am* 1988;19:575-80.
47. Vince KG, Insall JN, Kelly MA. The total condylar prosthesis: 10- to 12-year results of a cemented knee replacement. *J Bone Joint Surg [Br]* 1989;71-B:793-7.
48. Barton-Hanson NG. Outcome measures in total knee replacement. Poster presentation SICOT. Sydney, Australia, April 1999.
49. L'Insalata JC, Stern SH, Insall JN. Total knee arthroplasty in elderly patients: comparison of tibial component designs. *J Arthroplasty* 1992;7:261-6.
50. Zicat B, Rorabeck CH, Bourne RB, Devance PA, Nott L. Total knee arthroplasty in the octogenarian. *J Arthroplasty* 1993;8:395-400.
51. Anderson JG, Wixson RL, Tsai D, Stulberg SD, Chang RW. Functional outcome and patient satisfaction in total knee patients over the age of 75. *J Arthroplasty* 1996;11:831-40.
52. Dawson J, Carr A. Outcomes evaluation in orthopaedics. *J Bone Joint Surg [Br]* 2001;83-B:313-5.