

# A POPULATION STUDY IN THE PROVINCE OF ONTARIO OF THE COMPLICATIONS AFTER CONVERSION OF HIP OR KNEE ARTHRODESIS TO TOTAL JOINT REPLACEMENT

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**OBJECTIVE:** To evaluate the complication rates after conversion of hip and knee fusions to total joint replacements in the Province of Ontario.

**DESIGN:** A retrospective cohort study.

**PATIENTS:** Those who had undergone an elective conversion of a hip or knee fusion to a total joint replacement during fiscal year 1993 through 1996, as captured in the Canadian Institute for Health Information and Ontario Health Insurance Plan databases.

**OUTCOME MEASURES:** Inhospital complications and length of initial hospital stay, revision, infection, amputation and repeat fusion rates within 4 years.

**RESULTS:** Conversion of hip and knee fusion to total joint arthroplasty was generally performed by high-volume surgeons in high-volume hospital settings. Forty hip and 18 knee replacements involved conversion of a previous fusion. Conversion of a hip fusion was associated with a 10% infection rate, a 10% revision rate and a 5% resection arthroplasty rate due to infection within 4 years of the conversion. Conversion of a knee fusion was associated with an 11% infection rate, and a more than 5% revision rate at 4 years. Over 16% of patients who underwent conversion of a knee fusion required removal of the components (for various reasons) within the first 4 years.

**CONCLUSIONS:** There is a high rate of complications after conversion of a hip or knee fusion to a total joint arthroplasty. These issues must be carefully considered and discussed with the patient before any conversion procedure.

**OBJECTIF :** Évaluer les taux de complications après une conversion d'une arthrodèse de la hanche et du genou en arthroplastie totale en Ontario.

**CONCEPTION :** Étude rétrospective de cohortes.

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**PATIENTS :** Personnes qui avaient subi une conversion élective d'une arthrodèse de la hanche ou du genou en arthroplastie totale au cours des exercices 1993 à 1996, selon les données saisies dans les bases de données de l'Institut canadien d'information sur la santé et du régime d'assurance-maladie de l'Ontario.

**MESURES DE RÉSULTATS :** Complications pendant le séjour à l'hôpital et durée du séjour initial, taux de révision, d'infection, d'amputation et d'arthrodèses répétées dans les quatre ans.

**RÉSULTATS :** La conversion d'une arthrodèse de la hanche et du genou en arthroplastie totale a été réalisée en général par des chirurgiens à volumes élevés dans des contextes hospitaliers à volumes élevés. Quarante remplacements de la hanche et 18 remplacements du genou ont comporté une conversion à la suite d'une arthrodèse antérieure. La conversion d'une arthrodèse de la hanche a entraîné des taux d'infection de 10 %, de révision de 10 % et d'arthroplastie de résection de 5 % attribués à l'infection dans les quatre années qui ont suivi la conversion. La conversion d'une arthrodèse du genou a entraîné des taux d'infection de 11 % et de révision de plus de 5 % à quatre ans. Plus de 16 % des patients qui ont subi une conversion d'une arthrodèse du genou ont dû subir une ablation des composants (pour diverses raisons) au cours des quatre premières années.

**CONCLUSIONS :** Il y a un taux élevé de complications après une conversion d'une arthrodèse de la hanche ou du genou en arthroplastie totale. Il faut peser attentivement ces enjeux et en discuter avec le patient avant de procéder à toute conversion.

Since the advent of low-friction joint arthroplasty, the procedure of choice for end-stage degenerative arthritis of the hip or knee has been total joint arthroplasty. Primary joint fusion is now rare except for cases of uncontrolled joint sepsis or for patients considered too young for primary total joint replacement.<sup>1,2</sup> After many years, the abnormal gait and loading patterns associated with fusion lead to changes in the adjacent ipsilateral and contralateral joints. After fusion of the hip joint, patients commonly have ipsilateral knee pain as well as problems in the contralateral hip and lower back.<sup>3,4</sup> It has been suggested that before considering knee joint arthroplasty below an ipsilateral fused hip, a takedown of the hip fusion should be considered to avoid undue stress and wear on the knee arthroplasty.<sup>5-8</sup>

There have been few reports regarding the outcome for patients who have undergone a conversion of an ankylosed or fused hip<sup>3,5,6,9-13</sup> or knee<sup>14-21</sup> joint to a total joint arthroplasty. The purpose of this study was to review the early complications after conversion procedures of hip and knee fusion to total joint replacement performed over 3 years in the Province of Ontario.

## MATERIALS AND METHODS

Canadians are covered by a universal health care plan that is adminis-

tered by the Ministry of Health in each province. The Ontario Health Insurance Plan (OHIP) maintains a record of all patient encounters with the health care system in the Province of Ontario for which a bill is generated. Since 1992, the OHIP database contains unique patient identifiers as well as hospital and physician identifiers. A service date, diagnostic and procedural code is also included. Although OHIP procedural codes are detailed and highly specific, diagnostic categories are quite vague and incomplete. For this study we supplemented the OHIP information with diagnostic information from the Canadian Institute for Health Information (CIHI). The CIHI collects information regarding inpatient discharges from all health institutions in the province, including International Classification of Diseases, ninth revision diagnostic codes. CIHI does collect procedural codes using the Canadian Classification of Procedures categories, but these procedural categories are not very detailed in the area of arthroplasty surgery. It is not readily possible to distinguish between primary and revision total knee arthroplasty, for example. For the purposes of this investigation, the OHIP and CIHI datasets were linked by a unique identifier to provide detailed information regarding diagnosis and services.

A cohort of patients who had un-

dergone hip and knee replacement operations between April 1993 and March 1996 was identified with use of an algorithm designed to include only elective primary total hip or knee replacements. One year of data before the first admission were available to assess patient comorbidity. A minimum of 1-year follow-up (with a maximum of 4-years' follow-up) was available for all patients. Patients whose OHIP files contained the code R248 (takedown of knee fusion) or R553 (takedown of hip fusion) were considered to have undergone takedown of a joint arthrodesis at the time of total joint replacement. CIHI codes for serious complications at the time of initial hospitalization were recorded for each patient. These included stroke, myocardial infarction, surgical mishaps, and others as previously described.<sup>22</sup> The patient cohort was then followed in both the OHIP and CIHI database for a minimum of 1 year (maximum of 4 years) during which time revision surgery and readmission for infections related to the joint replacement were sought. The initial length of hospital stay, occurrence of urinary tract infections (UTI) at initial admission and deep venous thrombosis (DVT) within 3 months of initial admission were also documented.

The cohort of hip replacement patients was then linked to the Ontario mortality file to obtain accurate infor-

mation regarding patient deaths since the CIHI dataset captures only in-hospital deaths.

Descriptive statistics were used to compare the demographics of those who underwent elective joint replacement with fusion takedown and those who underwent only elective joint replacement. Using generalized estimating equations, we then modelled complications, revision, infection and length of hospital stay as a function of whether or not fusion takedown had taken place. Adjustment was made for patient age, gender, diagnosis, comorbidity, admission year, follow-up period and the volume of procedures performed by the treating surgeon and hospital. Logistic regression was used for binary outcomes and ordinary least squares regression for continuous outcome variables.

**RESULTS**

Between April 1993 and March 1996, 12 952 primary elective total hip replacements were performed in the Province of Ontario. Forty (0.3%) of these cases were coded as hip fusion takedowns. Of the 14 352 primary elective total knee replacements performed during the same time period, 18 (0.1%) were coded as takedown of a knee fusion.

**Hip replacements**

When compared with routine elective primary total hip replacements, hip fusion takedowns were performed on younger patients who were healthier and more likely to be male with diagnoses other than degenerative arthritis (Table I). Hip fusion takedowns were also more likely to be performed in high-volume hospitals by high-volume surgeons.

The rate of complications after conversion of a fused hip to a total hip arthroplasty was much higher than for routine elective primary hip replace-

ments (Table I). Forty-five percent of patients with conversion of a hip fusion had a serious complication at the time of index admission: there was a deep infection in 10%, another 10% required revision and 5% underwent Girdlestone resection arthroplasty due to infection within 4 years. The risk of these complications remained much higher than for routine total hip replacement recipients even after adjust-

ing for age, gender, diagnosis, comorbidity, admission year, follow-up period, and surgeon and hospital volume (Table II).

None of the patients who had undergone conversion of a hip fusion to total hip arthroplasty underwent hip repeat fusion. No hip fusions were performed after routine elective total hip arthroplasty (i.e., without hip fusion takedown) during the follow-up

**Table I**

**Demographics and Crude Complication Rates After Total Hip Replacement With and Without Previous Hip Fusion**

Demographic factor	Fusion	No fusion
Mean age, yr	58.5	66.9*
Follow-up, yr	2.5	2.5
Male sex, %	60	43†
Diagnosis not osteoarthritis, %	47.5	8.9‡
Comorbid conditions > 1, %	0	2.7
Mean hospital volume, no./yr	181	136†
Mean surgeon volume, no./yr	76	60†
Mean length of hospital stay, d	10.3	10.3
Complication present at index admission, %	45	10.9‡
Revision within 4 yr, %	10	1.8*
Infection within 4 yr, %	10	1.3§
Girdlestone procedure performed within 4 yr, %	5	0.3§
Urinary tract infection at index admission, %	0	2.1
Deep venous thrombosis within 3 mo of index admission, %	0	2.2

Student's *t*-test was used for continuous variables, the  $\chi^2$  test for categorical variables (with continuity correction). Fisher's exact test was used when 1 or more cells had fewer than 5 expected counts. Comparisons between patients who underwent hip fusion takedown and those who did not may be biased since no adjustment was made for other potentially confounding factors.

\**p* < 0.01, †*p* < 0.05, ‡*p* < 0.0001, §*p* < 0.001

**Table II**

**The Odds of Complications After Total Hip Replacement for Patients With and Without Previous Hip Fusion**

Outcome	Odds ratio (with:without fusion)	95% confidence interval
Girdlestone resection	14.9	3.1–70.6
Infection	6.9	2.3–20.3
Complications during index admission	6	3.1–11.5
Revision	4.9	1.7–14.3

An odds ratio > 1 implies that the complication is more likely to occur after conversion of a previous hip fusion. In all cases the estimate is adjusted for age, gender, diagnosis, comorbidity, admission year, follow-up time, and surgeon and hospital volume. All odds ratios are statistically significant at *p* < 0.05.

period. There was only one hip disarticulation in the entire cohort, performed for infection in a patient without hip fusion takedown.

**Knee replacements**

Patients who underwent conversion of a fused knee to a total knee arthroplasty tended to be younger and were more likely to be male (Table III). They were also more likely to have a diagnosis other than osteoarthritis compared with patients who underwent routine elective total knee replacement. In contrast to patients who had hip fusion, those who had knee fusion tended to have more comorbid conditions than those who underwent routine knee replacement, although this finding did not reach statistical significance (Table III). Although over 85% of patients who had routine primary total knee replacements underwent patellar resurfacing or patelloplasty, just under 28% of those who had conversion of a knee fusion underwent patellar replacement or patelloplasty ( $p < 0.0001$ ) (Table III). There was no statistically significant difference in the surgeon or hospital volume for knee fusion takedown compared with routine total knee arthroplasty (Table III).

With the size of our cohort, we were unable to find a statistically significant difference in the rate of serious complications during the initial hospitalization after takedown of a knee fusion versus routine total knee arthroplasty ( $p > 0.05$ ). Length of hospital stay was significantly increased by 2.8 days on average ( $p < 0.05$ ). Two patients (11.1%) had an infection, and 1 (5.6%) required excision followed by an attempted revision and ultimately repeat fusion. The other patient underwent excision only. In total, 3 (16.7%) patients underwent excision arthroplasty after conversion of a fused knee to a total knee arthroplasty. Two of these ulti-

mately had their knees re-fused (including the one with infection).

There were no amputations after takedown of a knee fusion. Six amputations were required in the group of patients who had routine elective total knee replacement. The overall rate of

amputations thus is 0.04 % for the entire patient cohort.

After adjusting for age, gender, diagnosis, comorbidity, admission year, follow-up time and surgeon and hospital volume, the risk of an excision arthroplasty or repeat fusion was sta-

**Table III**

**Demographics and Crude Complication Rates After Total Knee Replacement With and Without Previous Knee Fusion**

Demographic factor	Fusion	No fusion
Mean age, yr	60.9	69.6*
Follow-up, yr	2.8	2.4
Male sex, %	61.1	38.0†
Diagnosis not osteoarthritis, %	33.3	8.8*
Comorbid conditions > 1, %	11.1	3.2§
Mean hospital volume, no./yr	106.8	143.9
Mean surgeon volume, no./yr	38.5	49.5
Mean length of hospital stay, d	13.1	10.3†
Complication present at index admission, %	22.2	10.3
Revision within 4 yr, %	5.6	2.0
Fusion or re-fusion within 4 yr, %	11.1	0.1‡
Excision within 4 yr, %	16.7	0.8‡
Patellar replacement or patelloplasty, %	27.8	85.3‡
Infection within 4 yr, %	11.1	2.2
Urinary tract infection at index admission, %	5.6	2.0
Deep venous thrombosis within 3 mo of index admission, %	5.6	2.6

Student's *t*-test was used for continuous variables, the  $\chi^2$  test for categorical variables (with continuity correction). Fisher's exact test was used when 1 or more cells had fewer than 5 expected counts. Comparisons between patients who underwent hip fusion takedown and those who did not may be biased since no adjustment was made for other potentially confounding factors.

\* $p < 0.01$ , † $p < 0.05$ , ‡ $p < 0.0001$ , § $p < 0.001$

**Table IV**

**The Odds of Complications After Total Knee Replacement for Patient With and Without Previous Knee Fusion**

Outcome	Odds ratio (with:without fusion)	95% confidence interval
Knee resection arthroplasty	15.8	4.3–58.5
Infection	4.0	0.9–17.8
Complications during index admission	2.7	0.9–8.3
Revision	1.9	0.25–14.5
Repeat fusion of the knee	82.0	15.3–44.2

An odds ratio > 1 implies that the complication is more likely to occur after conversion of a previous knee fusion. In all cases the estimate is adjusted for age, gender, diagnosis, admission year, follow-up time, and surgeon and hospital volume. A 95% confidence level that includes 1 suggests that the result was not significant at  $p < 0.05$ . Significant findings are highlighted.

tistically significantly higher after conversion of a fused knee to a total knee arthroplasty than for a routine total knee replacement ( $p < 0.05$ , Table IV). The adjusted risk of undergoing excision was almost 16 times higher (95% CI 4.3 to 58.5) after knee fusion conversion than the risk of excision after routine primary total knee replacement (Table IV). The adjusted risk of undergoing surgical repeat fusion after conversion of a fused knee to a total knee arthroplasty was 82 times higher (95% CI 15.3 to 44.2) than the risk of fusion for routine primary total knee recipients (Table IV).

DISCUSSION

Since the advent of low friction total hip and knee arthroplasty, the indications for primary fusion of these joints have diminished considerably. Careful attention to technical detail at the time of hip fusion may allow subsequent conversion to a total hip arthroplasty while

providing relatively good function for many years.<sup>23,24</sup> The main indication for knee fusion remains uncontrolled sepsis after failed total knee arthroplasty.<sup>25-27</sup> Tuberculosis and joint sepsis from other causes may result in auto-fusion of the hip or knee joint, occasionally with less than optimal positioning.<sup>11,21</sup>

Disabling back pain, ipsilateral knee and contralateral hip pain are the most common reasons for considering conversion of a hip fusion to a total joint arthroplasty. Conversion of a hip fusion to a total hip arthroplasty has also been recommended before considering an ipsilateral knee replacement.<sup>5-7,28,29</sup> Romness and Morrey<sup>29</sup> were unable to find a significant difference in short-term outcomes between patients who had undergone knee replacement with and without conversion of an ipsilateral hip fusion to a total joint replacement. Successful replacement of an arthritic hip on the same side as a previous knee fusion has been reported.<sup>30</sup>

Several English-language studies with 10 or more patients have been published since 1980 relating to conversion of fused or ankylosed hips<sup>6,10-13,31</sup> (Table V) and knees with zero degrees of preoperative motion (Table VI).<sup>14,16,20</sup> Mullen<sup>19</sup> presented excellent results of total knee arthroplasty performed on stiff knee joints.

Strathy and Fitzgerald<sup>13</sup> found that conversion of an ankylosed hip to a total hip arthroplasty was more likely to fail in patients who had undergone attempts at fusion previously and in patients under the age of 50 years. Kilgus and associates<sup>12</sup> confirmed these observations. The OHIP and CIHI datasets used in our study do not provide sufficient information to distinguish between spontaneous ankylosis and previous surgical fusion. Lubahn and associates<sup>6</sup> noted that 2 patients with ankylosing spondylitis demonstrated less functional improvement than others after hip fusion takedown. Reikeras and colleagues<sup>31</sup> found that

Table V

Experience With Hip Fusion Conversion to Total Hip Arthroplasty Since 1980

Demographic factor	Series						
	Current study	Reikeras et al, 1995 <sup>31</sup>	Kilgus et al, 1990 <sup>12</sup>	Strathy and Fitzgerald, 1988 <sup>13</sup>	Cameron and Jung, 1987 <sup>10</sup>	Hardinge et al 1986 <sup>11</sup>	Lubahn et al 1980 <sup>6</sup>
No. of joints	40	46	41	80	13	112	17
Surgically fused, %	NA	NA	31.7	80	100	65.2	29.4
Follow-up, yr	1-4	5-13	7	9-15	1-9	2-19	< 9
Mean age, yr	58.5	58	53	49.8	49	NA	58.5
Male, %	60	19.6	48.8	NA	53.8	NA	70.6
Infection, %	10	0	9.8	11.3	0	1.8	5.9
Excision, %	0	0	0	1.3	0	0	5.9
Revision, %	10	15.2	0	25	0	2.7	5.9
Repeat fusion, %	0	0	0	0	0	0	0
Function	NA	74% needed aids after (none before), 76% good & excellent	Fewer aids	45% good or excellent	69.2% good and excellent	Relief of back pain and function	Relief of back and ipsilateral knee pain
Mean range of movement (flexion)	NA	NA	87°	NA	88°	NA	72°

The information presented in the table is taken from English-language publications since 1980 reporting on at least 10 patients after conversion of a hip fusion to a total joint replacement.

poor hip abductor function resulted in the need for postoperative crutch support in 74% of their patients (none had used aids preoperatively). Nonetheless they noted good or excellent results in 76% using the modified Postel d'Aubigne scoring system. Although the absence of hip abductors has generally been considered a contraindication to total joint replacement surgery, Besser<sup>9</sup> has described a muscle transfer to compensate for absent abductors of the hip in conversion of fused hip to total hip arthroplasty.

Cameron and Hu<sup>16</sup> reported a series of knee fusion takedowns after formal surgical fusion. They reported good or excellent functional results in 58.8% according to the Hospital for Special Surgery scoring system. In contrast, Naranja and colleagues<sup>20</sup> experienced a 57% total complication rate after conversions of ankylosed knees to total knee replacements with a satisfactory outcome in only 29%. Patients with poor outcomes were significantly older and had poor knee flexion after the conversion operation.

Mahomed and colleagues<sup>18</sup> reported on 2 cases in which soft-tissue expansion was used before conversion of an arthrodesed knee to mobilize the extensor mechanism and to increase the amount of soft-tissue cover. Holden and Jackson<sup>17</sup> noted that retention of the patella facilitated exposure during conversion of a knee fusion to a total knee arthroplasty.

Population data review is limited to the examination of only those variables available in the dataset. It is not possible to determine whether the patients identified by OHIP procedure codes for takedown of hip or knee fusion had previously undergone surgical arthrodesis or whether their preoperative range of motion was in fact zero. Moreover, the population data contain no information regarding the functional outcome of patients having undergone the procedure.

Previous reports that measured patient function before and after hip fusion takedown have failed to demonstrate a significant improvement in global rating scores as a result of con-

version to total hip arthroplasty,<sup>11,12,31</sup> although Cameron and Jung<sup>10</sup> found that the majority of their patients would have the procedure again. Many patients continued to experience ipsilateral knee and back pain.<sup>12,31</sup> Hip conversion may actually compromise gait because of difficulty in powering the mobile hip with weak abductor muscles, resulting in a persistent limp and the potential need for walking aids in patients who did not require them before the procedure.<sup>31</sup> Other reported problems include postoperative hematoma,<sup>10,11</sup> sciatic nerve palsy,<sup>11</sup> dislocation,<sup>6</sup> persistent stiffness<sup>6,12</sup> and intraoperative femoral fracture.<sup>6,10</sup>

The literature suggests that knee range of motion after conversion is often limited to less than 65°<sup>14,20,21</sup> with the development of knee pain that may not have been present preoperatively. The extensive soft-tissue release required for this operation has resulted in tibial tubercle avulsion and tendon rupture.<sup>14,16,20,21</sup>

## CONCLUSIONS

Although detailed clinical and functional information is not available using administrative information, the population data used in this study do provide a provincial overview regarding these relatively uncommon procedures. We found that in Ontario, conversion of a fused hip or knee joint to a total joint arthroplasty is a rare operation being performed by high-volume surgeons in high-volume institutions. These procedures are associated with a high risk of early complications, including a greater than 20% risk of serious complications during the index admission, an infection rate of at least 10% within 4 years and a high risk of early revision or excision. With the small number of patients in the dataset, we were unable to identify any significant differences in complication rates by surgeon or hospital. The high

**Table VI**

**Experience With Knee Fusion Conversion to Total Knee Arthroplasty Since 1980**

Demographic factor	Series			
	Current study	Naranja et al, 1996 <sup>20</sup>	Cameron and Hu, 1996 <sup>16</sup>	Bradley et al, 1987 <sup>14</sup>
No. of joints	18	37	17	9
Follow-up, yr	1-4	0-20	1-10	2-6
Mean age, yr	60.9	53	59.1	55
Male, %	61.1	20	58.8	11.1
Infection, %	11.1	13.5	18	0
Excision, %	16.7	1*	0	0
Revision, %	5.6	24.3	12	11.1
Repeat fusion, %	11.1	5.4	11.8	0
Function	NA	42.9% housebound	58.8% good or excellent	Longer walking tolerance
Mean range of movement (flexion)	NA	-7°-62°	0-84°	2°-64°

The information presented in the table is taken from English-language publications since 1980 reporting on at least 10 patients after conversion of a knee fusion (0° of preoperative motion) to a total joint replacement.

\*Above knee amputation

rate of complications should be carefully considered and discussed with patients before proceeding with the operation.

References

1. Barnhardt T, Stiehl JB. Hip fusion in young adults. *Orthopedics* 1996;19:303-6.
2. Benaroch TE, Richards BS, Haideri N, Smith C. Intermediate follow-up of a simple method of hip arthrodesis in adolescent patients. *J Pediatr Orthop* 1996;16:30-6.
3. Callaghan JJ, Brand RA, Pedersen DR. Hip arthrodesis. A long-term follow-up. *J Bone Joint Surg [Am]* 1985;67:1328-35.
4. Sponseller PD, McBeath AA, Perpich M. Hip arthrodesis in young patients. A long-term follow-up study. *J Bone Joint Surg [Am]* 1984;66:853-9.
5. Amstutz HC, Sakai DN. Total joint replacement for ankylosed hips. Indications, technique, and preliminary results. *J Bone Joint Surg [Am]* 1975;57:619-25.
6. Lubahn JD, Evarts CM, Feltner JB. Conversion of ankylosed hips to total hip arthroplasty. *Clin Orthop* 1980;153:146-52.
7. Perugia L, Santori FS, Mancini A, Manili M, Falez F. Conversion of the arthrodesed hip to a total hip arthroplasty. Indications and limitations. *Ital J Orthop Traumatol* 1992;18:145-53.
8. Brewster RC, Coventry MB, Johnson EW Jr. Conversion of the arthrodesed hip to a total hip arthroplasty. *J Bone Joint Surg [Am]* 1975;57:27-30.
9. Besser MI. A muscle transfer to replace absent abductors in the conversion of a fused hip to a total hip arthroplasty. *Clin Orthop* 1982;162:173-4.
10. Cameron HU, Jung YB. Results of total hip arthroplasty without trochanteric osteotomy following hip fusion. *Orthop Rev* 1987;16:646-50.
11. Hardinge K, Murphy JC, Frenyo S. Conversion of hip fusion to Charnley low-friction arthroplasty. *Clin Orthop* 1986;211:173-9.
12. Kilgus DJ, Amstutz HC, Wolgin MA, Dorey FJ. Joint replacement for ankylosed hips. *J Bone Joint Surg [Am]* 1990;72:45-54.
13. Strathy GM, Fitzgerald RH Jr. Total hip arthroplasty in the ankylosed hip. A ten-year follow-up. *J Bone Joint Surg [Am]* 1988;70:963-6.
14. Bradley GW, Freeman MA, Albrektsson BE. Total prosthetic replacement of ankylosed knees. *J Arthroplasty* 1987;2:179-83.
15. Cameron HU. Role of total knee replacement in failed knee fusions. *Can J Surg* 1987;30:25-7.
16. Cameron HU, Hu C. Results of total knee arthroplasty following takedown of formal knee fusion. *J Arthroplasty* 1996;11:732-7.
17. Holden DL, Jackson DW. Considerations in total knee arthroplasty following previous knee fusion. *Clin Orthop* 1988;227:223-8.
18. Mahomed N, McKee N, Solomon P, Lahoda L, Gross AE. Soft-tissue expansion before total knee arthroplasty in arthrodesed joints. A report of two cases. *J Bone Joint Surg [Br]* 1994;76:88-90.
19. Mullen JO. Range of motion following total knee arthroplasty in ankylosed joints. *Clin Orthop* 1983;179:200-3.
20. Naranja RJ, Lotke PA, Pagnano MW, Hanssen AD. Total knee arthroplasty in a previously ankylosed or arthrodesed knee. *Clin Orthop* 1996;331:234-7.
21. Schurman JR, Wilde AH. Total knee replacement after spontaneous osseous ankylosis. A report of three cases. *J Bone Joint Surg [Am]* 1990;72:455-9.
22. Kreder HJ, Deyo RA, Koepsell T, Swiontkowski MF, Kreuter W. Relationship between the volume of total hip replacements performed by providers and the rates of postoperative complications in the state of Washington. *J Bone Joint Surg [Am]* 1997;79:485-94.
23. Matta JM, Siebenrock KA, Gautier E, Mehne D, Ganz R. Hip fusion through an anterior approach with the use of a ventral plate. *Clin Orthop* 1997;337:129-39.
24. Murrell GA, Fitch RD. Hip fusion in young adults. Using a medial displacement osteotomy and cobra plate. *Clin Orthop* 1994;300:147-54.
25. Arroyo JS, Garvin KL, Neff JR. Arthrodesis of the knee with a modular titanium intramedullary nail. *J Bone Joint Surg [Am]* 1997;79:26-35.
26. Behr JT, Chmell SJ, Schwartz CM. Knee arthrodesis for failed total knee arthroplasty. *Arch Surg* 1985;120:350-4.
27. Knutson K, Hovelius L, Lindstrand A, Lidgren L. Arthrodesis after failed knee arthroplasty. A nationwide multicenter investigation of 91 cases. *Clin Orthop* 1984;191:202-11.
28. Garvin KL, Pellicci PM, Windsor RE, Conrad EU, Insall JN, Salvati EA. Contralateral total hip arthroplasty or ipsilateral total knee arthroplasty in patients who have a long-standing fusion of the hip. *J Bone Joint Surg [Am]* 1989;71:1355-62.
29. Romness DW, Morrey BF. Total knee arthroplasty in patients with prior ipsilateral hip fusion. *J Arthroplasty* 1992;7:63-70.
30. Bourne MH, Fox DL, Morrey BF. Long-term evaluation of hip arthroplasty in patients with an ipsilateral knee arthrodesis. *Clin Orthop* 1993;289:170-4.
31. Reikeras O, Bjerkreim I, Gundersson R. Total hip arthroplasty for arthrodesed hips. 5- to 13-year results. *J Arthroplasty* 1995;10:529-31.