# My orthopaedic surgeon suggests a unicompartmental knee replacement: a detailed look at the long-term outcomes of a single surgeon's practice

Samuel J Lynskey, Christopher M Frampton, Timothy G Lynskey

## ABSTRACT

**AIM:** This single surgeon case series with up to 29-year follow-up evaluated the survival of the Oxford unicompartmental knee replacement (UKR) for isolated medial compartment osteoarthritis.

**METHOD:** Four hundred and four knees in 330 patients were followed for between 12 days to 29 years, with an average of 13 years. Kaplan–Meier survival estimates were calculated using revision for total knee replacement and re-operation for any reason over 5-year intervals. Revision and reoperation rates per 100 component years were used to compare subsets, cemented and uncemented prostheses and Phase 2 and Phase 3 instrumentation.

**RESULTS:** Of 404 UKRs, 292 (72%) were cemented, 96 (24%) uncemented and 16 hybrid (4%); 137 (34%) were undertaken using Phase 2 instrumentation and 267 (66%) Phase 3 instrumentation. Estimated revision-free implant survival at 20 years was 78%, and estimated reoperation-free survival at 20 years was 72%.

**CONCLUSION:** Unicompartmental knee replacement is a very successful procedure, with 78% of knees remaining revision-free at 20 years. Progression of lateral compartment arthritis was the most common cause for revision, affecting 60% of revision cases. There was no significant difference in the revision or reoperation rate between cemented and uncemented prostheses or Phase 2 and minimally invasive Phase 3 instrumentation.

Unicompartmental knee replacement (UKR) has been a popular treatment since Ahlbäck discovered that knees with clinical osteoarthritis have isolated medial compartment degeneration.[1] Benefits of UKR include a shorter operative time, reduced hospital stay, lower blood loss, greater post-operative range of movement and higher activity level at the time of discharge than in total knee replacement (TKR).[2] In addition, long-term benefits include preservation of bone stock, lower morbidity, higher functional activity and a subjective feeling of a "normal knee" due to cruciate ligament preservation.[3] UKR is associated with higher revision rates compared to TKR; however, head-to-head, UKR performs better across multiple domains, and so patients must be encouraged to consider these factors.[4] Further, for those patients with predisposing comorbidities, a lower risk of thromboembolic and major cardiac events in UKR as compared to TKR is likely to be material and should also be discussed as part of the consent process.[5] Nevertheless, patients often elect to undergo joint replacement procedures based upon the recommendation of family members or friends. This mode of decision making, though influential, should not substitute for time spent in ensuring an understanding of the nature, benefits and risks of the procedure, as well as viable alternatives; and, in the case of UKR, what the options are if and when the prosthesis fails. As clinicians we are responsible for justifying our decisions and actions, and in order to enter into a model of shared decision making, the patient must be provided with transparent, robust and understandable information.[6] To do this accurately, the clinician must have a comprehensive understanding of these factors enabled by contemporaneous knowledge of the evidence as well as participation in self-audit.

UKR has been in use since 1970; however, there are few long-term case studies published.[5,7] This study is a retrospective single-surgeon case series of prospectively acquired data over a 31-year follow-up period. The primary aim was to review and report the survivorship of the Oxford UKR for isolated medial compartment osteoarthritis of the knee, as determined by revision to TKR or reoperation for any reason. The secondary aims were to compare the subsets of Phase 2 with Phase 3 instrumentation, as well as cemented with uncemented prostheses. Finally, we aimed to investigate and discuss causes of failure and report long-term functional scores associated with UKR.

## Methods

Included patients were those who underwent UKR with the Oxford prosthesis for isolated medial compartment osteoarthritis who satisfied the criteria according to the prosthetic designers.[8] Specifically, patients with fewer than 15 degrees flexion contracture, 100 degrees of flexion on the operating table, a correctable varus deformity in 20 degrees of knee flexion, a clinically or radiologically intact anterior cruciate ligament, full thickness cartilage loss in the anterior aspect of the medial compartment, but preserved posteriorly, and a lateral joint space of 5 millimetres or more on a valgus stress X-ray taken in 20 degrees of knee flexion were included.

### Primary outcome measures

Survival of the prosthesis was determined by identifying patients who underwent revision to TKR. These patients were captured through representation to the primary surgeon and by screening the New Zealand Joint Registry. Revision-free estimates were calculated for 5-year follow-up intervals using Kaplan–Meier estimates. Reoperation for any reason was determined by screening local hospital records and via telephone communication with the patient. Reoperation-free estimates were calculated for 5-year follow-up intervals using Kaplan–Meier estimates. The time to revision and reoperation was used to calculate a revision rate per 100 component years (py) with 95% confidence intervals (95% CI) using a Poisson approximation.

### Secondary outcome measures

Revision rates were used to compare the subsets, cemented and uncemented knees, and Phase 2 and Phase 3 instrumentation using Log-Rank tests. A two-tailed p-value less than 0.05 was taken to indicate a statistically significant difference between groups.

The chief investigator kept a database from 1 February 1991, the first surgery, until 28 November 2022, the last audit. The database was password protected and compliant with governing local ethics review requirements. Functional scores were determined using the Oxford Knee Score (OKS) obtained from the New Zealand Joint Registry. From the year 2000 onwards, all patients undergoing UKR surgery in New Zealand were posted a form asking them to complete an OKS. All those who responded were posted a further form at 5-yearly intervals out to a maximum of 15 years post-operation. Final follow-up was determined to be either the date the patient was deceased, underwent reoperation for any reason or the date of final review, specifically 28 November 2022. Additional information, including demographic data, were obtained from patient records, theatre logbooks, the New Zealand Joint Registry and the National Patient Database.

This audit was approved by the Taranaki District Health Board Ethics Committee and local iwi.

## Results

The total number of UKRs undertaken over the study period was 404 in 330 patients. No cases were lost to follow-up. One hundred and sixty-seven patients who underwent replacement were deceased at an average of 11.5 years, and 166 were still alive at an average of 17.3 years. The average prosthetic follow-up was 13 years (12 days–29 years). See Table 1.

Thirty-nine UKR patients survived over 20 years and 16 over 25 years, with the two longest survivors reaching 29 years.

The Kaplan–Meier estimate of survival using revision to TKR as the primary end point at 15 years was 84%, and at 20 years 78%. Fifty-one UKRs required revision to TKR, of which 60% were for progression of lateral compartment osteoarthritis. In this group four UKRs had a previous high tibial osteotomy (HTO) and two UKRs in one patient developed haemochromatosis. One patient on warfarin suffered recurrent haemarthroses, one developed rheumatoid arthritis and in one the medial compartment was overstuffed. Four knees became symptomatic of patellofemoral osteoarthritis and were revised to TKR for anterior knee pain. Four patients had revision to TKR following significant trauma. Two were twisting injuries resulting in anterior cruciate ligament (ACL) rupture and two suffered falls, the first with a delayed presentation of a lateral tibial plateau fracture and the second from a mountain bike with posterior cruciate and medial collateral ligament injury.

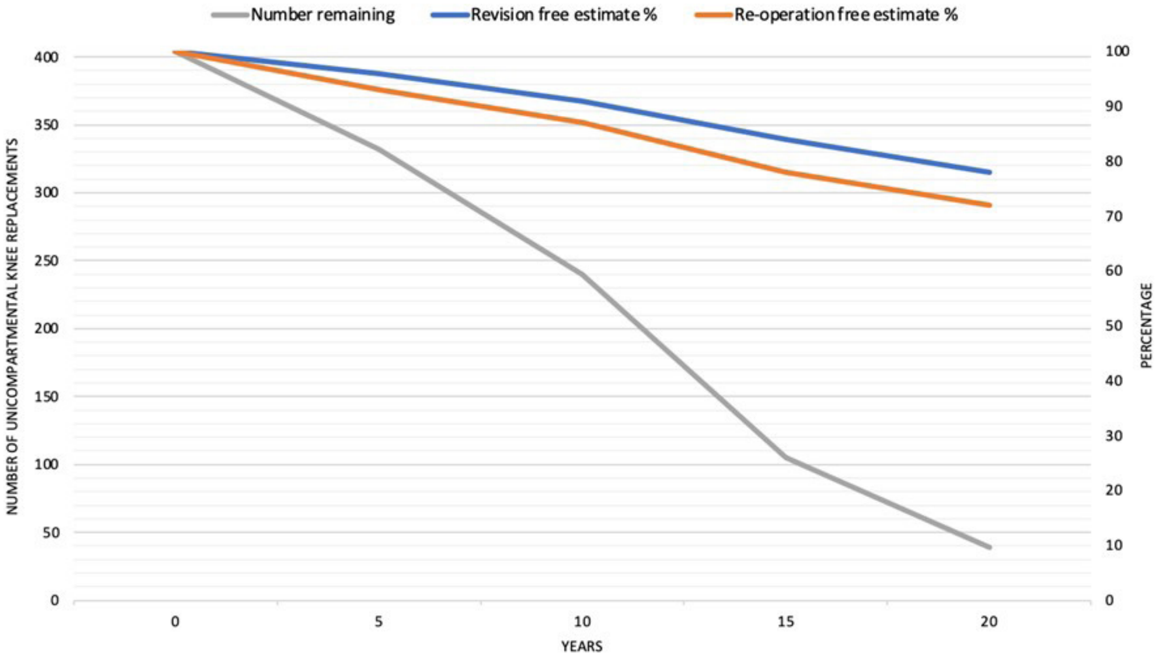
**Table 1:** Procedural breakdown and follow-up data, including revision, prosthetic fixation and instrumentation type.

| | |
|---|---|
| Procedures | 404 |
| Patients | 330 |
| Lost to follow-up | 0 |
| Male/female % | 57/43% |
| Average age at operation | 70.8 (range: 51–94) |
| Average follow-up | 13 years (range: 12 days–29 years) |
| Alive | 166 (41.1%) |
| Deceased | 167 (41.3%) |
| Revision to total knee | 51 (12.6%) |
| Other reoperation | 20 (5%) |
| Cemented prostheses | 292 (72%) |
| Uncemented | 92 (24%) |
| Hybrid (2 reverse) | 16 (4%) |
| Phase 2 | 137 (34%) |
| Phase 3 | 267 (66%) |

**Table 2:** Reasons leading to revision to total knee replacement.

| | N=51 | Average time to revision (years) | Range of time (years) |
|---|---|---|---|
| Progression of lateral compartment arthritis | 31 | 10 | 1.3–24 |
| Loosening tibial component | 8 | 10.3 | 1–16 |
| Progression patellofemoral arthritis | 4 | 8 | 1–14 |
| Significant traumatic injury to knee | 4 | 5.2 | 3.3–16.6 |
| Heterotopic ossification with stiffness | 1 | 10 | |
| Deep infection | 1 | 0.7 | |
| Chronic regional pain syndrome, stiffness | 1 | 13 | |
| Pain without identifiable cause | 1 | 4.5 | |

**Figure 1:** 5-yearly Kaplan–Meier revision and reoperation survival estimates.




Of the cases that went on to have TKR, 17 were revised using primary total knee components; 28 required a stemmed tibia; five required both stemmed tibia and femur; and only one patient required a stemmed femur alone. See Table 2.

Estimated reoperation-free survival at 15 years was 78%, and at 20 years 72% (see Figure 1).

There were 20 reoperations where a UKR had been preserved. The most common cause was a worn or fractured mobile bearing (see Table 3). One was size 3, and the remainder size 4. Medical records were available for all patients and showed no further surgery was undertaken in any of the 20 UKRs until death or the final review date. Of note, the survival time after re-operation is shown but was not used in any of the calculations of survival or reoperation rate.

Mobile bearing instability *without* dislocation was seen in two uncemented UKRs. The mobile bearing dislocation rate in the cemented UKRs was 0.3%, and in the uncemented UKRs it was significantly higher at 3% (p=0.05). One patient suffered bilateral recurrent mobile bearing dislocation and was treated by conversion to a fixed bearing prosthesis, Oxford-M. No obvious cause for dislocation was found.

One patient suffered mobile bearing impingement causing discomfort and a click in full extension due to bone regrowth over the anterior aspect of a cemented femoral component, which required bone resection. There were two cases of trauma where the UKR was retained; a fall causing a tibial plateau fracture, which was internally fixed, and direct trauma to the knee as a result of a cow causing an anterior cruciate ligament rupture, which was revised to the Oxford-M prosthesis.

The revision rate per 100 component years for all UKRs with 4,653 component years was 1.10 (range 0.82–1.44) and the reoperation rate was 1.52 (range 1.19–1.92). There was no significant difference in the revision rate between cemented and uncemented prostheses or between Phase 2 and Phase 3 instrumentation as shown in Table 4. Revision for patellofemoral arthritis occurred in four cases in our series (1%). Bearing wear requiring replacement was noted in six UKRs, all of which were cemented.

Returned OKS showed 91% excellent or good scores at 15 years (see Table 5).

**Table 3:** Reason for reoperation, other than conversion to total knee replacement.

| Reason for reoperation | Procedure | N=20 | Time to reoperation | Further surgery | Survival after reoperation |
|---|---|---|---|---|---|
| Worn or fractured mobile bearing | Replace bearing | 6 | 12 (10–15) years | No | 12 (4–17) years |
| Mobile bearing instability | Insert larger bearing | 2 | 1 & 6 years | No | 7 & 10 years |
| Isolated post-operative mobile bearing dislocation | Replace bearing | 2 | 5 & 6 weeks | No | 2 & 13 years |
| Recurrent mobile bearing dislocation | Convert to Oxford-M | 2 in one patient | 0.5 & 4.7 years | No | 9 years |
| Anterior mobile bearing impingement | Arthroscopic debridement | 1 | 2 years | No | 13 years |
| Loose femoral component | Re-cement | 1 | 4 years | No | 12 years |
| Medial ligament injury, bearing instability | Insert larger bearing | 1 | 2.5 years | No | 7 years |
| Impinging osteophyte cruciate footprint of tibia | Excise osteophyte | 1 | 2 years | No | 13 years |
| Cement loose body | Remove loose body | 1 | 1.4 years | No | 14 years |
| Irritation overhang tibial component, 4mm | Revise tibia size A to AA | 1 | 16 weeks | No | 10 years |
| Traumatic anterior cruciate ligament rupture | Convert to Oxford-M | 1 | 16 weeks | No | 10 years |
| Traumatic proximal tibial fracture | Internal fixation | 1 | 3 weeks | No | 10 years |

**Table 4:** Revision and reoperation rates per 100 component years.

| | Total number of UKRs | Sum of component years | Number of UKRs revised | Rate/100 component years | Lower 95% CI | Upper 95% CI | p-value |
|---|---|---|---|---|---|---|---|
| **Revision** | | | | | | | |
| All UKRs | 404 | 4,653 | 51 | 1.10 | 0.82 | 1.44 | |
| **Reoperation** | | | | | | | |
| All UKRs | 404 | 4,653 | 71 | 1.53 | 1.19 | 1.92 | |
| **Revision** | | | | | | | |
| Cemented | 294 | 3,849 | 44 | 1.14 | 0.83 | 1.53 | 0.93 |
| Un-cemented | 102 | 756 | 7 | 0.93 | 0.37 | 1.91 | |
| **Reoperation** | | | | | | | |
| Cemented | 294 | 3,849 | 55 | 1.43 | 1.08 | 1.86 | 0.06 |
| Un-cemented | 102 | 756 | 16 | 2.12 | 1.21 | 3.44 | |
| **Revision** | | | | | | | |
| Phase 2 | 137 | 1,906 | 22 | 1.15 | 0.72 | 1.75 | 0.99 |
| Phase 3 | 277 | 2,748 | 29 | 1.06 | 0.71 | 1.52 | |
| **Reoperation** | | | | | | | |
| Phase 2 | 137 | 1,906 | 29 | 1.52 | 1.02 | 2.18 | 0.92 |
| Phase 3 | 267 | 2,748 | 42 | 1.53 | 1.10 | 2.07 | |

**Table 5:** Returned Oxford Knee Scores (OKS).

| | 6 months | 5 years | 10 years | 15 years |
|---|---|---|---|---|
| Number returned | 208 | 115 | 67 | 11 |
| Average score | 40 | 41 | 42 | 41 |
| Excellent | 47% | 64% | 64% | 36% |
| Good | 34% | 23% | 28% | 55% |
| Fair | 13% | 6% | 3% | 9% |
| Poor | 5% | 5% | 3% | 0% |

OKS: excellent >41; good 34–41; fair 27–33; poor <27.[9]

## Discussion

This single-surgeon series with long-term follow-up reports the survivorship of the Oxford UKR for isolated medial compartment osteoarthritis of the knee, as determined by revision to TKR or reoperation for any reason. Further, we compared subsets of Phase 2 with Phase 3 instrumentation and cemented with uncemented prostheses. We also described causes of failure and reported long-term functional scores associated with UKR.

When patients reach the stage of considering joint replacement surgery for isolated medial compartmental osteoarthritis, the possible options include UKR, TKR or HTO. In general, the chief investigator reserves HTO for patients under 50 because of less predictable and durable results and a slower recovery and, when necessary, a more difficult revision to TKR.[10] The benefit of UKR over TKR in a matched cohort of patients is clear—with less pain, higher activity level, longer discomfort-free walking time, greater satisfaction with functional activities and higher probability of reporting "satisfied" or "very satisfied" up to 1 year post-operatively.[11] Our study adds to the weight of evidence supporting "excellent" or "good" knee function in 91% of respondents, with 15-year follow-up. Patients undergoing TKR also have a higher risk of complications including myocardial infarction, thromboembolism and stroke, plus higher readmission rates and mortality; such that if 100 patients receiving TKR underwent a UKR instead, there would be one less death and three more reoperations in the first 4 years post-operatively.[12] The decision then for surgeons to offer, *and for patients to consent to*, UKR for all its benefits must be balanced against the *known greater* revision and reoperation rate.[4,12]

Long-term survival of Oxford medial compartment replacement for unicompartmental osteoarthritis in our series is similar to the New Zealand Joint Registry for all UKR, which shows a survival for reoperation at 15 and 20 years of 83% and 76% respectively.[13] Compared with previous reports regarding the Marmor UKR—a prosthesis previously used at our institution—the Oxford showed a higher earlier revision rate with survival at 10 years of 91% compared with 95%, but a similar survival at 15 years and more UKRs surviving beyond 20 years.[14] Similar to the Marmor UKR, in our series the most common cause for revision was for progression of disease involving the lateral compartment followed by loosening of the tibial component.[15]

With time and experience there have been modifications to the original indications for the Oxford UKR.[8] Previous HTO and bone loss with grooves on the lateral side of the patellofemoral joint are now contraindications to UKR.[16] In our review we have chosen not to exclude patients with prior HTO or pre-existing patellofemoral joint osteoarthritis in the analysis, which in part may explain marginal differences in revision rates compared with other case series; nonetheless, these are comparable to those reported in the New Zealand Joint Registry for the Oxford UKR. We recommend therefore that patients presenting with prior HTO or patellofemoral joint disease not necessarily be excluded from UKR, but rather be carefully evaluated on a case-by-case basis.

Regarding our secondary aim, we found no significant difference in the revision rate between cemented and uncemented UKRs. This finding is discordant with a meta-analysis reporting significantly better survival in the uncemented Oxford UKR; however, these data were limited by a relatively shorter follow-up period of 18.3 months (ranging from 18.3 months to 7.6 years).[17] Our reoperation rate per 100 component years for cemented prostheses was 1.43 (95% CI 1.08–1.86), and was consistent with the New Zealand Joint Registry figure of 1.37 (CI 1.27–1.48). However, the uncemented prostheses rate of 2.12 (CI 1.21–3.44) did not achieve overlap with New Zealand Joint Registry figure of 0.87 (CI 0.77–0.97).[13] Nine of the 20 UKRs that underwent reoperation were uncemented and included three cases involving significant trauma at 3 weeks, 16 weeks and 2.4 years, and two additional cases of mobile bearing dislocation at 5 weeks and 24 weeks post-operatively. The relatively small total number of uncemented UKRs combined with the number of early reoperations in this series undoubtedly contributed to the higher revision rate. Our finding of a statistically significantly lower mobile bearing dislocation rate in the cemented UKRs (0.3%) compared with uncemented UKRs (3%) ($p=0.05$) is consistent with other reports.[18] We question whether these bearing-related problems were indicative of a learning curve for uncemented UKRs, tibial component subsidence over time or some other factor. We question if the intraoperative selection of bearing thickness should take into account possible future subsidence. Whether tibial component subsidence is associated with early or late mobile bearing dislocation, however, remains to be elucidated and warrants further investigation.

The introduction of Phase 3 instrumentation facilitated minimally invasive surgery that has been reported to be associated with suboptimal implant positioning and a higher revision rate.[19] Of note, however, we found no difference in the revision rate with the adoption of Phase 3 instrumentation.

Surgeon volume has been shown to influence revision rate. The ideal percentage of knee replacements that are deemed eligible for UKR has been estimated to be between 6 and 50%.[20] The chief investigator's percentage would be approaching the higher figure but, as in other series, this would reflect referral pattern rather than extended indications.[16] An excellent or good OKS of 91% at 15 years in our series compares favourably with Joint Registry (84%) and other studies (79%).[13,16]

In the event of complications necessitating further surgery and where the indications for UKR still exist we have preferred to preserve the UKR. Contrary to the Oxford Group, in cases of progression of arthritis we preferred to revise to a TKR despite the UKR components still being well fixed.[16] The exception to this is in a younger patient with recurrent mobile bearing dislocation or anterior cruciate ligament rupture through injury where literature supports conversion to fixed bearing UKR designs.[21] The most commonly reported reason for reoperation for any reason was symptomatic progression of arthritis, which occurred in 35 knees (49%). This finding is consistent with literature and occurs most commonly in the lateral compartment.[16,22,23] Reported progression of patellofemoral arthritis is common, but revision for this problem is low and reported as 3%, as compared to 1% in our study.[18] Reoperation for mobile bearing exchange occurred in only 1.5% of patients in our series, all of which were cemented prostheses and were either 3 or 4mm as recommended by the designers.[16] Further, these mobile bearings did not demonstrate macroscopic evidence of impingement on retrieval, suggesting alternate causes for failure other than overstuffing or impingement.

The primary industry in our region is farming and workplace trauma as a cause for revision in our series is noteworthy. We could not find a similar incidence of injuries in other comparable studies.[16,22,23] WorkSafe New Zealand statistics show farm assistants, labourers and agricultural workers are more likely to suffer injuries at work than other self-employed people, with the majority being soft tissue injuries and 6% being fractures or dislocations.[24]

Strengths of this study include a mean length of follow-up of 13 years with no loss to follow-up. Additionally, we have detailed and discussed the reasons for revision or reoperation in all but one case that had pain without an identifiable cause and was not improved by revision.

Limitations of this series includes the absence of radiological, limb alignment and range-of-motion assessment data. Further, adjustment for comorbid disease was not assessed in determining revision and reoperation rates. There is also a possibility of reporting bias with respect to our OKS, given the diminishing response rate over time. Many of our UKRs survived well into the third decade; however, we did experience a number of bearing-related complications and we therefore suggest that a prospective randomly controlled trial of fixed and mobile bearing UKRs would be valuable.

This study serves as a tool for personal audit and adds to the body of literature regarding URK demonstrating excellent long-term results. Although many factors should be taken into account when considering joint replacement including patient, technical and rehabilitative factors, we feel that this paper will enable clinicians, as it has our practice, to give patients presenting with medial compartment osteoarthritis of the knee comprehensive, long-term information necessary to make an informed decision.

## Conclusions

Unicompartmental knee replacement is a very successful procedure that has undergone a number of changes over the years to improve patient outcomes and enable less invasive implantation. Patients can be advised their UKR has a 78% chance of surviving 15 years and a 72% chance of surviving 20 years without further surgery. The chances of excellent or good knee function are 91%. If further surgery is necessary, there is a 28% chance of leaving a functioning UKR intact and a 72% chance of needing conversion to a total knee. The most common reason for further surgery leaving the UKR intact has been to replace a worn or dislocated meniscal bearing, which has an overall chance of 1.5%. The most common cause of needing to convert the UKR to a TKR has been progression of arthritis in the remainder of the knee. Traumatic injury to the UKR can result in the need for further surgery and the chances of this are 2%. The risks of infection and perioperative mortality within the first 2 weeks are both 0.25%. Over time there have been changes to instrumentation and prosthesis design to allow minimally invasive surgery, which has not resulted in an increase in complications.

#### COMPETING INTERESTS

These authors have no relevant financial or non-financial interests to disclose.

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#### AUTHOR INFORMATION

Samuel J Lynskey: Orthopaedic Registrar, Department of Orthopaedic Surgery, Geelong University Hospital, Geelong, Australia; Affiliate Academic, School of Medicine, Faculty of Health, Deakin University, Waurn Ponds, Geelong, Australia.

Christopher M Frampton: Statistician, University of Otago Christchurch, Christchurch Central, New Zealand; Statistician, Statistecol Consultants Ltd, Christchurch Central, New Zealand.

Timothy G Lynskey: Orthopaedic Surgeon, Department of Orthopaedic Surgery, Taranaki Base Hospital, New Plymouth, New Zealand.

#### CORRESPONDING AUTHOR

Timothy G Lynskey: Orthopaedic Surgeon, Department of Orthopaedic Surgery, Taranaki Base Hospital, Private Bag, New Plymouth 4310, New Zealand. E: t.lynskey@xtra.co.nz

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