The safety and efficacy of bilateral simultaneous total hip replacement
AN ANALYSIS OF 2063 CASES

E. Tsiridis, G. Pavlou, J. Charity, Ev. Tsiridis, G. Gie, R. West
From Leeds General Infirmary, Leeds, England

Comparison of the safety and efficacy of bilateral simultaneous total hip replacement (THR) and that of staged bilateral THR and unilateral THR was conducted using DerSimonian-Laird heterogeneity meta-analysis. A review of the English-language literature identified 23 citations eligible for inclusion. A total of 2063 bilateral simultaneous THR patients were identified. Meta-analysis of homogeneous data revealed no statistically significant differences in the rates of thromboembolic events (p = 0.268 and p = 0.365) and dislocation (p = 0.877) when comparing staged or unilateral with bilateral simultaneous THR procedures. A systematic analysis of heterogeneous data demonstrated that the mean length of hospital stay was shorter after bilateral simultaneous THR. Higher blood transfusion requirements were expected following bilateral simultaneous THR than staged or unilateral THR, and surgical time was not different between groups. This procedure was also found to be economically and functionally efficacious when performed by experienced surgeons in specialist centres.

Bilateral simultaneous total hip replacement (THR) was first reported by Jaffe and Charnley in 1971.1 Over the last three decades numerous authors have attempted to define the efficacy and safety of this procedure, compared with unilateral THR2-5 or staged bilateral procedures.6-10 Advocates of bilateral simultaneous THR suggest that it leads to an overall reduced hospital stay,10 shorter anaesthetic and surgical times,6 faster rehabilitation and improved cost-effectiveness.11 It is argued, however, that it is associated with an increased rate of complications, including deep-vein thrombosis (DVT),2 and increased medical morbidity,12 leading to a suboptimal functional outcome.13

There is recent evidence to suggest advantages of bilateral surface replacement of the hip when compared with a staged procedure.14

In view of these conflicting reports, we conducted a thorough search of all the English-language literature and carried out a meta-analysis, where appropriate, in an attempt to provide clear recommendations on bilateral simultaneous THR.

Materials and Methods

Identification of studies. We used the Medline (1960 to 2007),15 Cochrane,16 Web of Knowledge,17 Embase18 and Ovid19 databases to identify papers written in English only. The following terms and boolean indicators were used in the search: bilateral, unilateral, staged, hip arthroplasty, complications, function, outcome, bleeding, hospital stay, safety, and thromboembolism. In an attempt to identify all relevant literature, the reference lists of all papers identified electronically were searched. Further strategies to identify all pertinent literature included a manual search of the tables of contents of issues from 1995 to 2007 of four major orthopaedic journals, including The Journal of Bone and Joint Surgery (American and British Volumes), the Journal of Arthroplasty and Clinical Orthopaedics and Related Research and the bibliographic sections in the relevant chapters of three major orthopaedic textbooks, including Campbell’s Operative Orthopaedics,20 The Adult Hip21 and Orthopaedic Knowledge Update; Hip and Knee Reconstruction.22

Extraction of data. The papers were classified according to whether they analysed bilateral simultaneous THR alone, bilateral simultaneous THR versus unilateral THR, or bilateral simultaneous THR versus a bilateral staged procedure. Extracted outcome data included the number and demographics of patients, patient positioning during surgery, surgical approach, intra-operative blood loss and transfusion requirements, operative time and duration of hospital stay. The types of prosth-
ses used were also recorded in order for us to compare cemented with uncemented implants. Complications were considered, along with functional outcomes and economic data, when available.

**Analysis of data.** Statistical analysis was conducted using STATA version 9.2 (Statacorp LP, College Station, Texas) using the ‘metan’ command, and the programme R version 2.4.0 (The R Foundation for Statistical Computing, Vienna, Austria). Data on thromboembolic events and dislocation rates were sufficiently homogeneous to permit a formal meta-analysis, as determined by the chi-squared test for heterogeneity. Statistical significance was defined for overall $\alpha$ error at $p < 0.05$. A random effects meta-analysis by the DerSimonian-Laird method was employed to reflect variations between studies. For data on hospital stay, blood loss, and operative time a considerable heterogeneity was detected. As it was deemed methodologically inappropriate to combine these results, no summarised data are reported. In these cases, we conducted a systematic review focused purely on the differences between studies.

### Results

**Literature search.** We identified 23 citations\(^1\)\(^{1-12,24-34}\) that were eligible for inclusion (Table I). The last search for papers to be included in the meta-analysis was performed in August 2007. Of those, six compared bilateral simultaneous with unilateral THR,\(^2,4,5,12,24,25\) five compared bilateral simultaneous THR with staged THR,\(^6-10\) two compared all three groups simultaneously,\(^11,26\) and ten looked exclusively at bilateral simultaneous THR with no control group.\(^1,3,27-34\) A prospective study design was used in five papers,\(^2,4,12,24\) but the remaining studies were retrospective.\(^1,5-11,25-34\) Only in two of the studies\(^9,22\) was a process of randomisation undertaken for patient selection. A total of 2063 patients underwent bilateral simultaneous THR in all papers identified, of which 765 were included in studies without control groups,\(^1,3,27-34\) 809 were compared with patients after unilateral THR,\(^2,4,5,12,24,25\) 482 were compared with staged THR,\(^6-11,25,26\) and seven compared with patients after either staged THR or unilateral THR for cost-effectiveness.\(^11\) A further literature search was conducted between September 2007 and February 2008 prior to pub-

### Table I. Details of all studies included in the meta-analysis with general conclusions

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<th>Number of BSTHR* patients</th>
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<td>Parvizi et al(^10)</td>
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* BSTHR, bilateral simultaneous total hip replacement
lication, to ensure that up-to-date results had been included. Three more papers35-37 were found. Their results are summarised and appraised in the main text.

**Meta-analysis of homogeneous data**

*Deep-vein thrombosis and pulmonary embolism.* In three studies a total of 242 patients after bilateral simultaneous THR were compared with 511 patients after staged THR (Fig. 1).7-9 The combined results showed no statistically significant difference in the rate of pulmonary embolism or DVT between the two groups (p = 0.268, 95% confidence interval (CI) 0.24 to 3.15).

Five studies were identified comparing a total of 654 patients after bilateral simultaneous THR with 646 patients after unilateral THR (Fig. 2).5,7,12,24,25 The study by Lorenze et al24 was excluded from the calculation as no complications were recorded. In order to ensure that the two groups were comparable, the incidences of DVT and pulmonary embolism were reported for the patients after unilateral THR were doubled. The study by Berend et al 5 had much lower rates of complications; consequently, the confidence intervals for the odds ratio are much wider. The study by Kim et al25 had a very high rate of complications and so the odds ratio is more accurately determined. This may be partly because they investigated the presence of thromboembolic events using a venogram, which is more sensitive and more specific in detecting DVT.38 However, no statistical difference between the two groups could be found (p = 0.365, 95% CI 0.91 to 3.18).

**Dislocation.** Comparison of dislocation rates was based on data from eight studies. A total of 998 patients after bilateral simultaneous THR were compared with 1832 patients after staged or unilateral THR (Fig. 3).2,5-9,12,24 The reported incidence of dislocation for unilateral THR was doubled to allow for a comparable analysis. No statistically significant difference between the groups was identified (p = 0.365, 95% CI 0.74 to 2.82).

**Systematic review of heterogeneous data**

*Blood loss.* There were 418 patients after bilateral simultaneous THR versus 595 patients after staged THR in five studies.6,8-10,26 Only one study26 found an increased blood loss after bilateral simultaneous THR. In the remaining four studies6,8,10 bilateral simultaneous THR was associated with reduced blood loss.

*Operating time.* Based on five papers6-10 the mean operating time of 360 bilateral simultaneous THR versus 624 staged THRs was evaluated. In the study by Eggli et al,7 the SD of the operating time was not recorded. We conservatively inferred a value of 50 minutes for each treatment group based on data from the other studies.6,8-10 We also compared 359 bilateral simultaneous THRs with 635 unilateral THRs from five studies2,4,12,24,25 after doubling the time reported for unilateral THRs, Ritter and Stringer2 did not report the SD of the operating time and a value reported in an earlier report12 by one of these authors was assigned. A variation in operating time was found, attributed to differ-
ences in patient positioning, surgical approach and type of prosthesis used.

Hospital stay. We compared 489 patients after bilateral simultaneous THR with 766 patients after staged THR, based on data from seven studies.6-11,26 We also compared 293 patients after bilateral simultaneous THR with 636 patients after unilateral THR by doubling the unilateral THR time.2,11,12,24 In all studies the duration of hospital stay was less for bilateral simultaneous THR.2,6-12,24,26

Economics. The economic impact of performing bilateral simultaneous THR was compared with staged or unilateral THR.2,6,8,10,11,24 After doubling the cost of unilateral THR for comparison purposes, bilateral simultaneous THR was observed to be more efficacious financially.

Other complications. Only those studies that made direct comparisons between bilateral simultaneous THR and staged or unilateral THR were analysed.2,5,6,8,10,12,24,26 Because of the scarcity of data, formal statistical analysis was not possible. Therefore, the incidence of cardiovascular complications, urological complications, peri-prosthetic fractures, deaths and heterotopic ossification was recorded when available. No significant differences were identified between the groups.

Cemented versus uncemented prostheses. A further analysis to evaluate the safety of cemented versus uncemented bilateral simultaneous THR was attempted. With regard to blood loss, six papers with 997 patients who underwent cemented bilateral simultaneous THR1,2,26,27,31,33 and four papers with 188 patients who underwent uncemented bilateral simultaneous THR were identified.6,10,29,32 No difference in the amount of blood loss was found.

With regard to thromboembolic events, eight studies for cemented1,2,12,26-28,31,32 and three for uncemented6,25,29 bilateral simultaneous THR were identified. Because of the scarcity and heterogeneity of the data, no formal statistical analysis could be performed. The mean rates of DVT and pulmonary embolism observed in each group were not considered directly comparable.

American Society of Anesthesiologists score.39 The majority of studies had strict inclusion criteria as to which patients were suitable for bilateral simultaneous THR, thereby introducing a selection bias for the conduction of analysis. Three studies attempted to allocate patients to bilateral simultaneous, staged or unilateral THR on the basis of pre-operative American Society of Anesthesiologists (ASA) scoring.4,8,9 In two studies,4,9 post-operative complication rates were found not to be increased for those patients with higher ASA scores. It is, however, expected that higher ASA score will affect the surgical outcome.8

Functional outcome. A functional evaluation of the patients was conducted in 14 studies.1,2,5,7,9,10,12,26,30-34 In three of these, the Harris Hip Score was used,5,9,10 whereas in five the Merle d’Aubigné and Postel score was used,1,6,30,32,33 and in three the Hospital for Special Surgery hip
In three studies no formal scoring system was used. Although the heterogeneity of data precluded any formal statistical comparison, cumulative evidence from our analysis suggests that bilateral simultaneous THR appears to be as efficacious as unilateral THR.

**Discussion**

**Deep-vein thrombosis/pulmonary embolism.** Meta-analysis of data for DVT and pulmonary embolism found no significant difference between bilateral simultaneous THR and staged THR (Fig. 1). The primary concern with bilateral simultaneous THR is the theoretically-increased risk of cardiopulmonary complications, in particular that of pulmonary embolism. The surgical insult from a prolonged procedure has traditionally been considered a predisposing factor for post-operative thromboembolic events. Furthermore, it has been suggested that the greatest insult occurs during the insertion of the femoral component. A bilateral simultaneous THR, would therefore be expected to double the risk of thromboembolic phenomena. Similarly, no statistical difference was identified when bilateral simultaneous THR was compared with unilateral THR (Fig. 2). Ritter and Stringer attribute these findings to the improved peri-operative thromboembolic prophylaxis and to early patient mobilisation, as well as to advances in hypotensive anaesthesia and cementing technique.

**Dislocation.** Based on the assumption that patients undergoing bilateral staged THR will have a pathological painful contralateral hip one would expect this group to mobilise slower in the immediate post-operative period compared with the bilateral simultaneous THR group. This in itself would predispose to a lower risk of dislocation in view of slower and less strenuous post-operative activity.

We found no statistical difference when comparing bilateral simultaneous with staged and unilateral THR. **Blood loss.** Three studies pointed to an increased total blood loss with staged THR. Alfaro-Adrián et al commented that surgeons undertaking bilateral simultaneous THR may well be more conscious of on-table blood loss and therefore pay more attention to haemostasis. However, Salvati et al and Berend et al reported an increased total blood loss after bilateral simultaneous THR compared with staged THR. These results may be explained by the differences in operative techniques between authors. With regard to blood transfusion, however, the observation is different. Alfaro-Adrián et al found that patients are more likely to be transfused following bilateral simultaneous THR, as
blood loss is cumulative in one surgical sitting. Parvizi et al\textsuperscript{10} confirmed this observation and attributed it to an increased use of intra-operative blood salvage techniques in bilateral simultaneous THR.

In addition to the previous arguments, timing between the two stages of THR may well affect the need for transfusion. This timing has been reported to vary between three\textsuperscript{9} and ten months.\textsuperscript{8} Bhan et al\textsuperscript{9} noted that increased blood transfusion requirements in bilateral simultaneous THR had no cumulative effect on the incidence of systemic complications. Egol et al\textsuperscript{10} recommend pre-operative autologous blood donation for patients scheduled for bilateral simultaneous THR.

Operating time

**Patient positioning and surgical approach.** Only Shih and Ho\textsuperscript{6} demonstrated clearly that bilateral simultaneous THR took less time than staged THR. According to our analysis, all other studies\textsuperscript{7-10} found no difference in the operating time between bilateral simultaneous and staged THR. The positioning of the patient and the surgical approach both have a role to play in the duration of surgery. Shih and Ho\textsuperscript{6} used an anterolateral approach without a trochanteric osteotomy with the patient in the supine position. Two surgeons were simultaneously involved, one closing the first wound while the other moved on to the contralateral hip, thereby saving 20 to 30 minutes in the overall time. In addition, a single anaesthetic obviously favours bilateral simultaneous over staged THR.

When analysing the operating time between bilateral simultaneous THR versus twice the time of the unilateral THR\textsuperscript{2,4,12,24} we reached the same conclusion. In one study\textsuperscript{2} of bilateral simultaneous THR, however, a trochanteric osteotomy was routinely used, leading to an increase in the overall operating time.

**Type of fixation (cemented/uncemented).** Lorenze et al\textsuperscript{24} using cemented prostheses, found no difference between bilateral simultaneous THR and twice the unilateral THR operating times. Kim et al\textsuperscript{25} using an uncemented acetabular component and randomised patients to a cemented or cementless femoral component, found that operating times for bilateral simultaneous THR were shorter overall. Shih and Ho\textsuperscript{6} using exclusively uncemented prostheses, found that operating time was shorter for bilateral simultaneous compared with staged THR.

In summary, a number of variables influence operating time; however, some authors have reported that in high-volume centres there is no difference with regard to operating time among bilateral simultaneous, staged or twice the time needed for a unilateral THR\textsuperscript{2,24}

**Hospital stay.** The length of hospital stay reflects the speed of recovery and also has a significant correlation with the economics of the procedure. Therefore, it is an important indicator of the efficacy and safety of bilateral simultaneous THR. Analysis of all pertinent studies\textsuperscript{6-11} showed that the length of hospital stay for bilateral simultaneous THR was shorter. Eggli et al\textsuperscript{7} found a statistically significant difference between bilateral simultaneous and staged THR, with a mean hospital stay of five to six days longer for the latter. In addition, they commented that the combined effects of a shorter hospital stay and a single use of the operating theatres resulted in a 30% reduction in the cost for bilateral simultaneous THR.

**Economics.** The economic impact of conducting bilateral simultaneous THR versus staged or unilateral THR was analysed in seven papers\textsuperscript{2,6,8,10,11,23,37} Ritter and Stringer\textsuperscript{2} found that bilateral simultaneous THR cost 30% less than two unilateral THR procedures. Shih and Ho\textsuperscript{6} reported that a unilateral THR costs on average $5480, whereas bilateral simultaneous THR costs $6064. They commented that bilateral simultaneous THR had significant economic advantages, considering that the complication rates between the two procedures were similar. Reuben et al\textsuperscript{11} in agreement with other reports\textsuperscript{8,10,24} found a significant reduction in the cost of bilateral simultaneous THR, of the order of approximately 25%, compared with unilateral THR. Contrary to these findings, Berend et al\textsuperscript{12} found that both the hospitals and the surgeons experienced a potential reduction in their reimbursement after bilateral simultaneous THR. In the majority of the reports it appears that this is cost-effective, primarily because of the reduced length of hospital stay, but also because of the single operating and anaesthetic session.

**Other complications.** Based on observational analysis of all comparative studies\textsuperscript{2,5,10,12,24} there was no difference in the rate of post-operative complications among the groups. Furthermore, Berend et al\textsuperscript{12} found no difference in the intra-operative complications between bilateral simultaneous and staged THR. It is interesting to note, however, that Ritter and Randolph\textsuperscript{12} demonstrated a higher incidence of heterotopic ossification in the bilateral simultaneous THR group. Welters et al\textsuperscript{33} who performed a retrospective study of bilateral simultaneous THR only, reported relatively low rates of heterotopic ossification in this group. They attributed this to their post-operative protocol, which included prophylactic administration of indomethacin or piroxicam for ten days, starting on the day of surgery. Weinstein et al\textsuperscript{34} in a study comparing bilateral simultaneous THR in patients over and under 75 years old, showed that the elderly were more likely to be admitted for telemetry to rule out a myocardial infarction; however, the rate of confirmed myocardial infarction was not significantly different between the two groups, showing that bilateral simultaneous THR is safe. In a recent report by Huotari et al\textsuperscript{35} on the incidence of 365-day mortality and deep infection rates in bilateral simultaneous and unilateral THR, no statistically significant differences were observed, confirming a previous study by Tarity et al\textsuperscript{36} reporting the 60-day mortality after bilateral simultaneous THR. These results are in line with our systematic analysis.

**Type of fixation (cemented/uncemented)**

**Blood loss.** Comparing cemented\textsuperscript{1,2,26,27,31,32} with uncemented\textsuperscript{6,10,29,32} bilateral simultaneous THR we found that the mean blood loss was 1310 ml and 1319 ml, respectively. Therefore, no difference in blood loss was detected between the two types of fixation.
Thromboembolic events. Mechanical compression leads to an increase in intramedullary pressure, which in turn is thought to be an important pathogenic factor in the development of fat embolism. In addition, pressurisation of cement forces debris into the venous circulation. It has also been reported that cemented femoral components cause more severe and prolonged embolic cascades than uncemented components. It would be expected, therefore, that bilateral simultaneous THR would potentiate these phenomena.

Only three studies on uncemented bilateral simultaneous procedures were identified. The study by Kim et al exclusively compared cemented with uncemented bilateral simultaneous procedures and showed no significant differences between the overall numbers of fat globules in arterial and right atrial blood samples between the two groups, thus challenging the aforementioned findings. Shih and Ho compared bilateral simultaneous and staged THR performed with the use of uncemented components and found no difference between the two groups. Ritter et al also reported two incidents of DVT and one case of non-fatal pulmonary embolism among 92 patients after uncemented bilateral simultaneous THR. The authors of the latter study noted that the low incidence of thromboembolic events might be attributed to their vigorous pre-operative screening programme for patients at risk for DVT and pulmonary embolism and to the young age of their patients (mean age 54 years).

In our analysis, eight heterogeneous studies were identified for cemented bilateral simultaneous THR. No formal analysis was conducted for the studies on uncemented bilateral simultaneous THR, as there were only three identified complications. Therefore, only the mean rate of DVT and pulmonary embolism (2.3%) was recorded. For the two groups to be comparable, a pooled incidence of DVT and pulmonary embolism for the studies on cemented bilateral simultaneous THR was calculated (15%), regardless of the group's heterogeneity. The results should be interpreted with extreme caution, as the two groups were not directly comparable and the studies in the cemented group were heterogeneous. Thus, a significant weighting on the pooled calculation should not be inferred.

American Society of Anesthesiologists scoring for bilateral simultaneous versus staged/unilateral total hip replacements. The ASA grading is a major guiding tool in judging whether a patient is eligible for bilateral simultaneous THR. Theoretically, one would expect that patients with ASA grades 1 and 2 would tolerate more extreme surgical procedures with fewer complications. Cammissa et al did not exclude any patients on the basis of age or medical comorbidities and found a similar incidence of hypoxaemia in patients undergoing unilateral (33%) or bilateral simultaneous THR (35%). The authors reported that hypoxaemia was related only to the pre-operative levels of PaO2. Bhan et al found no significant difference in the complication rates between patients with ASA grades 1 and 2 against patients of ASA grades 3 and 4; however, the high ASA grade group comprised far fewer patients and their results should therefore be looked at with caution. On the other hand, Alfaro-Adrián et al found that patients with ASA grades 3 and 4 were more likely to develop complications. Tarity et al found no differences in the 90-day mortality rates; however, their study was admittedly selection-biased by including only younger patients with better ASA grades in the bilateral simultaneous THR group. The same conclusion was reached by Huotari et al, who also introduced selection bias in a 365-day mortality study, by enrolling fitter patients in the bilateral simultaneous THR group.

Analysis of functional results. Jaffe and Charnley reported on the functional outcome of patients after bilateral simultaneous THR. Although good scores for pain, walking ability and range of movement were achieved, the authors suggested that this was partly due to their patients being younger and fitter. Similar results have been reported by several other authors. When comparing uncemented staged with bilateral simultaneous THR, Shih and Ho found no differences in the post-operative pain or function between the two groups. Surprisingly, these authors found a reduced range of movement in the staged THR group and attributed this to differences between the two groups in underlying pathology. In a recent study by Berend et al, the patients in the bilateral simultaneous THR group failed to reach physiotherapy goals, requiring a higher portion of them to be transferred to rehabilitation facilities. In summary, cumulative evidence from our analysis suggests that bilateral simultaneous THR is as efficacious as a unilateral THR procedure.

Conclusion
Despite the limitations of searching only the English-language literature, identifying only two prospective randomised studies and restricting the meta-analysis to thromboembolic events and dislocation rates, we have been able to reach the following conclusions:

1. All potential candidates for bilateral simultaneous THR should undergo a detailed anaesthetic assessment pre-operatively, as the evidence for the safety of this procedure is largely based on the patient's ASA grade. ASA grades 1 to 2 are the safest for bilateral simultaneous THR.

2. Elderly patients are not by definition excluded from bilateral simultaneous THR, as age is not a contra-indication.

3. Higher blood transfusion requirements are expected following bilateral simultaneous THR than staged THR or unilateral THR, because of total cumulative loss in one sitting. We therefore strongly suggest that autologous blood transfusion, whether by pre-operative donation or by intra-operative blood salvage, be considered.

4. The risk of DVT or pulmonary embolism is not increased in bilateral simultaneous THR, provided that appropriate prophylactic measures are taken.
5. The risk of dislocation is not increased in bilateral simultaneous THR.
6. The overall surgical time is not different between bilateral simultaneous THR and staged THR.
7. The length of hospital stay is shorter after a bilateral simultaneous THR.
8. In carefully selected patients, bilateral simultaneous THR is more cost-effective.
9. Functional outcomes are similar after bilateral simultaneous THR and staged THR.
10. There is no difference in blood loss between cemented and uncemented bilateral simultaneous THR.
11. There is not enough evidence to allow safe conclusions on the risk for thromboembolic complications after cemented and uncemented bilateral simultaneous THR.
12. As the findings of our study are mostly based on investigations performed in specialist arthroplasty centres, we recommend that bilateral simultaneous THR be ideally undertaken in tertiary referral hospitals experienced in major hip surgery.

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