Single-stage bilateral total shoulder arthroplasty
A PRELIMINARY STUDY

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We compared six patients with a mean age of 70 years (49 to 80) with severe bilateral, painful glenohumeral joint destruction who underwent a single-stage bilateral total shoulder replacement, with eight patients of mean age 61 years (22 to 89) who underwent bilateral total shoulder replacement in two stages, at a mean interval of 18 months (6 to 43).

The overall function, pain and strength improved significantly in both groups. The subjective shoulder value, relative Constant score, active external rotation and the strength were improved significantly more in the single-stage group. Active elevation, abduction and overall function improved, significantly more in the single-stage group. Both the total duration of hospitalisation and the time off work per shoulder were substantially shorter in the single-stage group. The overall rate of complication was lower in the single-stage group.

Our findings indicated that single-stage bilateral total shoulder replacement yielded significantly better clinical results with shorter hospitalisation and rehabilitation than staged replacement, and was not associated with any increase in complications.

Single-stage bilateral total joint arthroplasty, primarily of the knee and the hip, is a recognised alternative to staged bilateral arthroplasty, with an excellent outcome in appropriately selected cases.1-4

Bilateral arthritis, whether osteo- or inflammatory, leading to incapacitating pain also occurs in the shoulder and a substantial number of patients ultimately undergo a bilateral total shoulder arthroplasty (TSA). Until recently, this has been successfully carried out as a two-stage procedure, involving separate episodes of anaesthesia and hospitalisation. However, there are situations in which a single-stage bilateral TSA would be preferable, such as to reduce the duration of disability, the total time to recovery, the number of admissions, the episodes of anaesthesia and the cost of treatment. The feasibility of a single-stage bilateral TSA has not been established, so patients cannot be informed about the potential benefits and the risks. In an effort to treat patients in good general health but with severe symptomatic bilateral shoulder disease, we have performed six single-stage bilateral TSAs (12 shoulders). The purpose of this preliminary study was to compare the outcome of these patients with that of eight who had undergone a staged bilateral TSA at our institution during the same time period.

Patients and Methods
Between 1996 and 2002, six patients (12 shoulders, group 1) had a single-stage TSA and eight (16 shoulders, group 2) a staged bilateral TSA.

In group 1 there were five women and one man. Their mean age was 70 years (49 to 80). All six were available for review with a mean follow-up of 36 months (23 to 80). The right side was dominant in all patients. Two patients had bilateral primary osteoarthritis with concomitant acromioclavicular arthritis, one had severe systemic lupus erythematosus, one chronic rheumatoid arthritis, one a crystal deposit arthropathy and one a bilateral cuff-tear arthropathy.

In group 2, there were seven women and one man. Their mean age was 61 years (22 to 89). All eight were available for review and had a mean follow-up of 45 months (24 to 71). Five had primary osteoarthritis, two rheumatoid arthritis and one psoriatic arthritis. All had symptomatic bilateral glenohumeral joint destruction which necessitated a TSA. Whereas the six patients in group 1 were equally disturbed by both shoulders, the eight in group 2 clearly had more symptoms on one side than on the other at the time of the initial operation. The mean interval between the two stages was 18 months (6 to 43).
Clinical assessment. Before and after surgery all the patients underwent an interview and a thorough clinical examination and were scored according to the system of Constant and Murley. This system is based on a scale of 100 points, a maximum of 35 points being given for subjective variables (pain, activities of daily living and functional use of the arm), a maximum of 40 for objective variables (range of movement) and a maximum of 25 for quantitative measurement of the strength of abduction. Active shoulder movement was measured with the patient seated. The range of flexion was assessed in the sagittal plane as the angle between the humeral shaft and the mid-thoracic line (not the vertical). Abduction was always measured with simultaneous maximal abduction of both arms as the angle of the humeral shaft with the mid-thoracic line. The Constant score for active external rotation was calculated by having the patient perform the five functional external rotation movements without touching the head with the hand, as described by Constant and Murley. The amount of internal rotation was determined by the highest spinous process which the patient could actively reach with his/her thumb. Abduction strength was measured with the patient standing, the arm abducted to 90° in the scapular plane, the elbow extended and the forearm pronated. Resistance was applied to the wrist and the abduction strength was measured on an Isobex dynamometer (Cursor SA, Bern, Switzerland) using the mean of three consecutive measurements for a duration of five seconds (B mode of the device). One point was given for each 0.45 kg (1lb) of strength measured. If 90° of abduction was not reached, abduction strength was automatically considered to be zero. The total score was also related to age- and gender-matched normal values which have been identified by Constant and Murley, and this relative value was called the Relative Constant score. In addition, the patients rated their operatively-treated shoulder as a percentage of the value of an entirely normal shoulder (i.e. 100%) using the so-called subjective shoulder value. An anatomical shoulder prosthesis (Zimmer, Warsaw, Indiana) was implanted in all patients except one with bilateral cuff-tear arthropathy. She had a single-stage TSA with a bilateral Delta III prosthesis (DePuy International, Raynham, Massachusetts) in combination with a bilateral transfer of the latissimus dorsi tendon.

Assessment of hospitalisation data. Data regarding the length of hospital stay and/or rehabilitation and duration of inability to work were recorded. In addition, all the anaesthetic records were reviewed to identify the patients’ physical status according to the American Society of Anaesthesiologists (ASA) classification. The intra- and post-operative blood loss through drains was confirmed as well as the post-operative reduction in haemoglobin concentration and transfusion requirements.

Operative technique. All the operations were performed in an identical fashion. The patients were positioned in the beach-chair position. For single-stage bilateral cases the dominant side was draped first. A deltopectoral approach was used in all the patients. The subscapularis was released using a superficial osteotomy of the lesser tuberosity, taking the subscapularis together with a piece of lesser tuberosity of an approximate thickness of 5 mm. The head was resected in an anatomical fashion. The biceps tendon was divided at the supraglenoid tubercle and tenodesed in the bicipital groove in all cases. A polyethylene glenoid component was used with cement in eight shoulders (67%) in group 1 and in all shoulders in group 2, and a metal-backed uncemented press-fit glenoid component without cement in four (33%) in group 1. The size of the head corresponded to the resected head in all the patients and the prosthetic stem was cemented in ten shoulders (83%) in group 1 and in all shoulders in group 2. The other two stems in group 1 were press-fit designs with the identical geometrical design of the prosthesis. After implanting the prosthesis a subscapularis repair was performed using a tension-band technique for the lesser tuberosity with two to three heavy, non-absorbable transosseous sutures. Drains were used in all patients and were removed between 24 and 48 hours post-operatively. For the single-stage procedures, the other side was then prepared and draped, a further dose of intravenous prophylactic antibiotic was administered and a TSA was carried out as described. Post-operatively, the operated arms were placed in slings. Passive movement was commenced immediately and active movement allowed as tolerated. The goal was to achieve full active elevation using both hands to assist. For the patients with a single-stage operation, for the first three days their personal hygiene requirements were cared for by the nursing personnel. After three days, patients started to address these needs themselves, using whichever arm was more comfortable.

Statistical analysis. Since certain data in group 1 were available for both shoulders and not individually (time of hospitalisation, blood loss, total time for anaesthesia), a mean value was calculated per shoulder. To allow comparison between the two groups, the data of the patient with bilateral Delta III prostheses were included for per-operative problems, but not for functional results.

Comparison of the pre- and the post-operative functional values was performed using the Wilcoxon test. The Mann-Whitney U test was used to compare the single-stage with the staged group. For both tests a p value of < 0.05 was considered to be statistically significant.

Results

Group 1 (Table I). The mean physical status score according to the ASA classification was 2 (2 to 3). The mean blood loss was 608 ml per shoulder (400 to 950) and there was a mean transfusion rate of 1.5 units per shoulder (0 to 3). The mean length of hospitalisation was seven days per shoulder (5 to 11). One patient with a history of alcohol abuse had an episode of post-operative psychosis due to a reaction to medication which resolved without specific treatment. At the final follow-up, all the patients indicated that they were very pleased with the single-stage TSA and would choose...
this treatment again if in the same situation. Of the six patients, four were retired but the remaining two were able to return to work after a mean period of 7.5 weeks (SD 2; 6 to 9).

Radiological evaluation revealed no malpositioning or loosening of any of the prosthetic components. Post-operatively there were no infections and no neurovascular complications.

**Group 2** (Table II). The mean physical status score according to ASA classification was 2 (1 to 3). The mean total blood loss per shoulder was 471 ml (200 to 800) and the transfusion requirement was a mean of 0.4 units per operated shoulder (0 to 1). Patients had a mean total length of hospital stay of ten days per shoulder (6 to 13). No peri-operative complications were seen. Of the eight patients, five were retired but the remainder were able to return to work after a mean period of 11 weeks (SD 3; 7 to 16) per shoulder.

After one year, one glenoid component demonstrated radiological aseptic loosening and had to be revised with the use of an allograft to fill the glenoid defect. One patient had a traumatic rupture of the subscapularis tendon, which was repaired. Another developed marked post-operative stiffness which was treated by an arthroscopic capsulotomy. At the final follow-up, all patients except the one with post-operative stiffness reported a subjective shoulder value of more than 70%. The patient with severe post-operative shoulder stiffness and capsulotomy had a subjective shoulder value of only 20%.

**Comparison of groups 1 and 2** (Tables III and IV). Patients in group 1 had a significantly better subjective shoulder value, relative Constant score and strength than those in group 2. Although a higher gain was seen in active anterior elevation, abduction, functional use of the shoulder and values for pain in group 1, this was not statistically significant. Patients in group 1 who were of working age returned to their original work earlier than those in group 2. No patient had to give up or reduce work after a TSA.

There were no serious peri-operative complications in either group. However, group 2 had significantly more late complications than group 1.

**Discussion**

In patients with primary osteoarthritis of the shoulder, it is not uncommon to see simultaneous bilateral involvement. Secondary osteoarthritis is usually related to a specific cause such as previous surgery, dislocation and instability, infection, avascular necrosis or inflammatory arthropathy. There may be bilateral involvement in secondary osteoarthritis and approximately 25% of the patients with inflammatory arthritis have severe bilateral disease.
Since the landmark publication of Neer, several reports have confirmed the efficacy of TSA for the treatment of such disorders. Single-stage bilateral total joint arthroplasty is not a new concept. Lazansky reported on a single-stage bilateral total hip arthroplasty in 1967, which was followed by another study on the use of a single-stage bilateral procedure by Jaffe and Charnley in 1971. It was concluded that bilateral single-staged operations were more beneficial than a staged approach. Some reports have found that single-stage bilateral total knee and hip arthroplasty is beneficial than a staged approach. Nonetheless, the data obtained from this study suggests that this may be associated with significant socioeconomic benefits. This is particularly important because functional gain was significantly higher for patients undergoing single-stage treatment in our series. The subjective shoulder value, the Constant score and the strength of the other, the standard staged procedure was proposed.

The outcome of the patients, even in this series, was surprising and showed unexpectedly greater advantages for a single-stage bilateral TSA. The patients in group 1 left the hospital earlier, their overall recovery was faster and if at working age they returned to work sooner than those in group 2. This is in agreement with studies reporting successful single-stage total hip or total knee replacement. Although not proven in our study, the data suggests that this may be associated with significant symptoms on both sides and could not clearly identify which shoulder they preferred to be operated upon first. If one shoulder was clinically worse than the other, the standard staged procedure was proposed.

To our knowledge, there are no reports of single-stage TSA in the literature. Nor are there established indications or contraindications for single-stage TSA. There is also no information on the post-operative course and the functional outcome of the single-stage versus the staged approach. Nonetheless, in a patient with severe symptomatic bilateral disease, the surgeon has to determine whether a single or staged TSA is more appropriate. Theoretical benefits of a single-stage approach include one episode of anaesthesia and hospitalisation, a single period of rehabilitation and, potentially, a shortening of the total length of hospital stay. Conversely, concerns include more post-operative pain, more complications secondary to prolonged anaesthesia and an increased risk of cardiopulmonary and thromboembolic events.

In our series, single-stage TSA was only considered if both shoulders were severely symptomatic and affected comparably. Relative contraindications were all relevant comorbidities with particular attention paid to concomitant heart disease and pulmonary dysfunction. The decision to proceed with a single-stage TSA was only taken after a detailed pre-operative discussion on the expected risk-benefit ratio was held between the surgeon, the patient and the anaesthetist.

The patients in our study were not randomised. Single-stage TSA was only considered if they had comparably severe symptoms on both sides and could not clearly identify which shoulder they preferred to be operated upon first. If one shoulder was clinically worse than the other, the standard staged procedure was proposed.

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were cemented. The geometrical design of the non-cemented components was identical to that of the cemented components. Since the quality of the anatomical reconstruction was radiologically identical and only one single glenoid component was radiologically loose, we feel that the use of cemented or non-cemented components is unlikely to have influenced any of the results.

Bilateral single-stage TSA has not been reported previously possibly because of the fear of post-operative systemic complications such as blood loss and thromboembolic disease, or local complications such as subscapularis detachment on compulsory active use of the shoulders. Total blood loss in the single-stage group was similar to that in the staged group, but transfusion requirement was significantly higher in the single-stage group. Thromboembolic complications, which have been reported as the main disadvantage in single-stage total hip and knee replacements, were not observed in our series. It may well be that the lower incidence of thromboembolic disease after TSA relates to the lower incidence of thromboembolic disease in any arthroplasty in the upper limb, thereby lowering the risk to the patient. The patients in our study did not feel unduly functionally handicapped in the early post-operative period, with their hygiene needs being addressed by the nursing staff in the first three days. Subscapularis detachment was not observed in our series. The success of the repair of the subscapularis may be related to the technique which we used. Overall, the rate of complication was less in the single-stage group.

Our results have shown a significantly better functional outcome with fewer complications for a single-stage approach. The procedure was carried out sequentially and could have been interrupted after the dominant side had been treated if any untoward intra-operative event occurred. We feel that on the basis of these results bilateral single-stage TSA is a promising option for selected patients with bilateral, severely symptomatic destruction of the shoulder.

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References