We used Laser Doppler flowmetry to measure the effect on the blood flow to the femoral head/neck junction of two surgical approaches during resurfacing arthroplasty. We studied 24 hips undergoing resurfacing arthroplasty for osteoarthritis. Of these, 12 had a posterior approach and 12 a trochanteric flip approach. A Laser probe was placed under radiological control in the superolateral part of the femoral head/neck junction. The Doppler flux was measured at stages of the operation and compared with the initial flux. In both groups the main fall in blood flow occurred during the initial exposure and capsulotomy of the hip joint.

There was a greater reduction in blood flow with the posterior (40%) than with the trochanteric flip approach (11%).

Resurfacing arthroplasty has become a common procedure for young people with severe arthritis of the hip joint. Two important complications, fracture of the femoral neck and aseptic loosening, may be associated with avascular necrosis (AVN) of the head of the femur owing to disruption of the blood flow during surgery. The reported incidence of fracture of the neck following resurfacing varies between 0% and 12%, commonly being in the range of 0% to 2%,1,4-6 Treacy et al1 noted a low incidence of AVN following resurfacing, but Milgram and Rana7 found evidence of this in 20 of 32 failed resurfacing arthroplasties. The mean blood supply to the femoral head comes from the ascending branches of the medial circumflex femoral artery,8 posterior to the hip joint.9,10 In a posterior approach to the hip these vessels may be damaged during dissection of the obturator externus and quadratus femoris11 and there is some evidence that the anterolateral approach leads to less disruption of blood flow.12 Ganz et al13 have described an alternative trochanteric flip approach that preserves these vessels during surgical dislocation of the hip, thus maintaining the blood supply.1 We carried out this study to test the hypothesis that a trochanteric flip approach would disrupt the blood supply to the femoral head/neck junction less than the posterior approach during resurfacing arthroplasty.

Patients and Methods
A total of 24 consecutive patients who had a metal-on-metal resurfacing arthroplasty (Corin group; Corin group, Cirencester, United Kingdom) for primary osteoarthritis of the hip were included in the study. Of these, 12 had a posterior and 12 a trochanteric flip approach according to the preference of the surgeon. Five surgeons were included; three used the posterior approach and two the trochanteric flip approach. There were eight men and four women in the posterior group and seven men and five women in the trochanteric group. The mean age in the posterior group was 51 years (31 to 59) and in the trochanteric group 56 years (30 to 70). All patients had Kellgren and Lawrence14 grade III osteoarthritis. The posterior group had six procedures on the left hip and six on the right, whereas the trochanteric flip group had three on the left and nine on the right. The mean operative time was 130 minutes (115 to 150) for the posterior and 155 minutes (130 to 180) for the trochanteric flip approaches.

All patients received general anaesthesia and were positioned in the lateral position. The skin incision was made according to the approach. After incision of the fascia lata, but before any further dissection was performed, a 2.0 mm drill was passed through the lateral femoral cortex into the superior part of the head/neck junction under fluoroscopic guidance (Fig. 1). A Laser Doppler probe (Moor Instruments Ltd, Axminster, United Kingdom) was inserted through the drill hole until the tip reached the head/neck junction as confirmed radiologically. The
superolateral part of the junction was used as the site of measurement in all patients, as the main blood supply to the head enters this area along the deep branches of the medial circumflex femoral artery.\textsuperscript{15} Blood flow was measured using a Laser flowmeter, which measures the movement of blood in the bone matrix using the Doppler principle. We used a class 1 Laser with a maximum power output of 2.5 mW and a wavelength of 785 nm (SD 10) with a 1.5 mm diameter, on a probe 10 cm long, to measure the blood flow in a volume of 1 mm\textsuperscript{3} from the tip of the probe. With the probe in position, the Doppler flux measurement was allowed to settle until a sinusoidal wave pattern which synchronised with the pulse rate was obtained.\textsuperscript{16} Flux was then measured for one minute and the mean value recorded as a proxy of mean blood flow during that minute. Laser Doppler flowmetry has been used extensively to measure blood flow in bone in both clinical and basic science settings.\textsuperscript{17-19} It has been validated as a tool for comparison and is thought to be useful in estimating circulatory compromise.

In each patient five measurements of blood flow at the superolateral aspect of the femoral head/neck junction were taken during each of the five stages of the operation. The first measurement was recorded at the time of incision of the fascia lata before any further soft-tissue dissection (Fig. 2). This was taken as the ‘baseline’ reading, and all other readings were recorded as a proportion of this value. The second reading was taken at the end of the soft-tissue dissection but before dislocating the hip, and the third after dislocating and relocating the femoral head back into the acetabulum. The fourth reading was taken at the end of insertion of the implant, after reduction but before closure. The final reading was taken at the end of closure of the soft tissue, including the osteotomy and the capsule.

**Statistical analysis.** Using the ‘baseline’ mean flux as a reference, proportional changes in flow were calculated for each patient at each stage of the operation. An unpaired t-test was used to compare changes in flow at each stage of the two surgical approaches. The p-values and 95% confidence intervals (95% CI) were calculated using SPSS version 12 (SPSS Inc., Chicago, Illinois).

**Results**

The mean blood flow compared with the baseline for each of the two approaches is shown in Figure 3. There was a measurable reduction in blood flow to the femoral head during both approaches to the hip joint. The largest fall occurred between the opening of the fascia lata (pre-exposure, pre-dislocation, Fig. 3) and the end of the initial soft-tissue dissection (post-exposure, pre-dislocation, Fig. 3). During the remainder of the operation the flow was
relatively constant. The mean reduction in femoral head blood flow during the posterior approach was 40% (95% CI 29 to 51), compared with 11% (95% CI 2 to 19) during the trochanteric procedure. This was statistically significant (p < 0.001). There was little recovery of blood flow during closure after completion of the arthroplasty.

Discussion
During the posterior approach to the hip, the deep branch of the medial circumflex femoral artery is almost certain to be divided. Previous Laser studies have shown that the resultant fall in blood flow to the femoral head may be as high as 60% during this approach. A study that used the oxygen concentration in the femoral head as a surrogate for blood flow showed a fall up to 60% during the soft-tissue dissection and a further 20% during component insertion. This is consistent with our measurement of a mean 40% reduction in flow during the posterior approach.

Previous Laser Doppler flowmetry studies of the hip joint and of the arthritic femoral head during hip resurfacing have focused on the blood flow to the femoral head, whereas we studied the femoral head/neck junction. This may be why we did not find that reaming the femoral head was a major cause of disruption to blood supply. Sevitt and Thompson found that the blood supply of the femoral head and of the head/neck junction were not identical. Even so, we did not find any previous study that had measured the blood flow in the femoral head and neck region using Laser Doppler flowmetry. We placed the probe in the head/neck junction, entering via the lateral cortex. In other studies the probe has been placed in the head via the femoral neck or directly through the surface of the head with the hip dislocated. Previous investigations have shown a reduction in blood supply to the head during surgical dislocation and with different positions of the hip during the operation. Studies that have measured flow with the hip dislocated are difficult to interpret. We took an initial flux measurement before dislocation and subsequent measurements with the hip relocated and the leg resting on the opposite side.

We undertook repeated re-insertion of the Doppler probe. By placing the tip of the 1 mm diameter probe at the apex of a 2 mm diameter tunnel, and by confirming the position with fluoroscopy, we made sure that all readings were taken from very similar locations in the bone. We have no reason to believe that there were any systematic differences in the accuracy of relocation of the probe between the groups with posterior or trochanteric flip approaches.

We have demonstrated a statistically significant greater reduction in flow with a posterior compared with a trochanteric flip approach, supporting the hypothesis that the trochanteric flip preserves more of the blood supply to the femoral head. This is consistent with another study that used the concentration of cefuroxime as an indirect measure of blood flow to compare the posterior with the transgluteal approach. The principal difference in flow between the approaches occurred during soft-tissue dissection and capsulotomy, when the terminal branches of the deep branch of the medial circumflex artery would be divided in the posterior approach but not with the trochanteric flip.

There are two main limitations to this study. First, even though we have demonstrated a statistically significant smaller reduction in blood flow in the trochanteric flip approach, the clinical significance of this is not clear. We do not know whether a reduction in intra-operative flow of 40% in the posterior approach is clinically important. Secondly, these intra-operative measurements do not tell us about the post-operative blood flow to the femoral head. It is possible that the blood flow may return early or late after surgery. Further studies are needed to answer two clinically relevant questions. First, does the intra-operative reduction in flow improve during the post-operative period, and if so, how long does that take? Secondly, what level of short-term vascular insult is sufficient to precipitate AVN?

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

Supplementary Material
A further opinion by Mr R. Spencer is available with the electronic version of this article on our website at www.jbjs.org.uk

References