We undertook a randomised controlled trial to compare the outcomes of skin adhesive and staples for skin closure in total hip replacement. The primary outcome was the cosmetic appearance of the scar at three months using a surgeon-rated visual analogue scale. In all, 90 patients were randomised to skin closure using either skin adhesive (n = 45) or staples (n = 45). Data on demographics, surgical details, infection and oozing were collected during the in-patient stay. Further data on complications, patient satisfaction and evaluation of cosmesis were collected at three-month follow-up, and a photograph of the scar was taken. An orthopaedic and a plastic surgeon independently evaluated the cosmetic appearance of the scars from the photographs. No significant difference was found between groups in the cosmetic appearance of scars at three months (p = 0.172), the occurrence of complications (p = 0.3), or patient satisfaction (p = 0.42). Staples were quicker and easier to use than skin adhesive and also less expensive. Skin adhesive and surgical staples are both effective skin closure methods in total hip replacement.

When considering improvements in surgical techniques and faster rehabilitation following total hip replacement (THR) attention should be given to the method of wound closure. Complications associated with skin closure, such as delayed healing or infection, may prolong recovery, resulting in increased morbidity, delayed discharge, increased costs and reduced patient satisfaction.

Wound closure aims to promote rapid healing of the skin with an acceptable scar and without complications such as dehiscence or infection. Three commonly used methods of closure are staples, sutures and skin adhesive. Surgical staples and sutures hold the edges of the skin together while it heals, and are commonly removed between ten and 14 days after surgery. Dissolvable sutures can also be used, which negate the need for removal. Skin adhesive is produced in a liquid form and polymerises on contact with tissue to form a strong bond that holds opposed skin edges together. The adhesive sloughs off about five to ten days after surgery, with no need for dedicated removal. The success of these skin closure methods has been assessed based on complication rates, cosmetic outcome, satisfaction, ease of use, speed of closure and cost. The most commonly used skin closure methods after THR are staples and sutures. However, the literature suggests that skin adhesive may offer advantages over these standard methods, such as ease of use and speed of application, with a similar cosmetic outcome and similar or higher patient satisfaction. To date, one randomised controlled study has compared skin adhesive, sutures and staples after lower limb joint replacement. This study showed skin adhesive to be an effective method of skin closure after THR, using wound complications as the primary outcome.

Our study aimed to compare outcomes of skin closure with skin adhesive and staples in THR, using a validated surgeon-based visual analogue scale (VAS) of cosmetic appearance at three months as the primary outcome measure. Secondary outcomes were evaluation of the scar using modified scar scales, patient satisfaction, complications, ease of use and speed of closure.

Patients and Methods

Between March and November 2007 we recruited 90 patients undergoing primary THR. Exclusion criteria were revision THR, a previous incision in the operative field, local skin conditions such as psoriasis, eczema or dermatitis, a history of keloid formation, underlying malignancy, peripheral vascular disease, insulin-dependent diabetes, and allergy to skin adhesive or metal staples. Ethical approval for the study...
was obtained from the local Research Ethics committee. All patients gave written informed consent.

Before surgery, basic demographic data, including age, gender, ethnicity, side of surgery, body mass index (BMI), diagnosis and previous other joint surgery, were collected.

All patients had the same post-operative care pathways and were blinded to the method of skin closure until the dressings were changed post-operatively. In-patient assessment took place at three to four days. A researcher collected information on the presence of oozing and wound infection, which was defined as the patient requiring antibiotics specifically for suspected wound infection. Patients whose wound was closed with staples had these removed between ten and 14 days post-operatively.

At three months data were collected on any wound complications and subsequent treatment from the medical records and the patient. Patients completed a 100 mm VAS for cosmetic appearance, where 0 indicated the worst outcome and 100 the best, and satisfaction with the scar with 0 indicating extreme dissatisfaction and 100 complete satisfaction, and a Likert scale for rating the appearance of the wound in relation to the expected appearance (1 = much better than expected, 2 = better than expected, 3 = as expected, 4 = worse than expected, 5 = much worse than expected). Patients were also asked for any comments regarding their scar or the method of skin closure, which were recorded in a free text box. A photograph of the scar was taken.

Evaluation of the cosmetic appearance of the scars was completed by a plastic surgeon (CME) using a modified version of the Hollander wound evaluation score and the Vancouver scar score, a Likert scale and a VAS.

The Hollander wound evaluation score assigns wounds a cosmetic score based on six features, graded as either present or absent. The score was modified to include only the three parameters relevant to the appearance of a scar at three months: step-off borders, contour irregularities and overall appearance, excluding those that cannot be evaluated once the initial stages of healing are complete after about ten days. For the purposes of this study a score of 3 was considered an optimal wound, and 2 or less was considered suboptimal.

The Vancouver scar score is used in clinical practice to document scar appearance. It was modified to two parameters: pigmentation on a scale from 0 to 3 (0 = normal, 1 = hypopigmented, 2 = mixed, 3 = hyperpigmented) and vascularity, again on a scale from 0 to 3 (0 = normal, 1 = pink, 2 = red, 3 = purple), excluding two parameters that could not be evaluated from a photograph. On this scale, lower scores represent a more normal appearance.

A Likert scale was used for the overall appearance of the scar (1 = poor, 2 = fair, 3 = good and 4 = very good) and the 100 mm VAS for cosmetic appearance as described above.

An orthopaedic surgeon (AWB) also evaluated the scars using the VAS for cosmetic appearance. Both the plastic and the orthopaedic surgeon were blinded to which method of skin closure had been used for each patient, and to each others’ scores.

Randomisation. The patients were randomised to skin closure using either Liquiband Surgical skin adhesive (Med-Logic Global Limited, Plymouth, United Kingdom) or staples (Appose UCL 35W, Tyco, Norfolk, Connecticut). Liquiband Surgical is a two-part skin closure system containing a fast setting n-butyl cyanoacrylate for initial wound closure and a secondary ocyt/butyrl; blend liquid bandage cyanoacrylate. Randomisation was performed, using the sealed envelope method, which involves identical sealed envelopes containing a card stating either ‘skin adhesive’ or ‘staples’ being opened by an independent researcher on the day of surgery. The operating surgeon was blinded to the skin closure method until the patient was in theatre.

Surgery details. All participating surgeons were either consultants or specialist registrars and operated on patients in both skin closure groups. All were trained in the use of the skin adhesive and had completed a minimum of five closures with this method prior to commencement of the study to eliminate bias. All surgeons had extensive experience of using surgical staples, as this is the standard method of skin closure at our centre.

The peri-operative care, with the exception of the method of skin closure was standardised, including antibiotic prophylaxis, thromboprophylaxis and use of OpSite (Smith and Nephew, London, United Kingdom) dressings for the wound. All patients had a posterolateral or anterolateral approach to the hip, and three layers of sutures prior to the randomised skin closure method; the fascia lata was closed with continuous no. 2 Vicryl, fat with interrupted no. 1 Vicryl, and the deep dermal layer with 00 Vicryl.

The skin closure method was timed by a researcher in a sub-sample of ten patients in each group. A stop-clock was started when the skin adhesive applicator or staple gun was first applied to the skin, and stopped when the skin was fully closed and the closure device removed. The length of the scar was measured and an ease of closure 100 mm VAS (where 0 indicated no problems to 100 implying impossibility of closure), was completed by the operating surgeon for these 20 patients.

Statistics. The power calculation was based on surgeon rating of the cosmetic appearance of the scar on the VAS at three months. With a minimal clinically important difference of 15 mm, a sample of 74 patients (37 in each group) was required to detect a difference between the two methods of closure at 80% power and a p-value of 0.05, which was increased to 90 patients to account for a potential 20% loss to follow-up.

Statistical analysis was completed using SPSS 12.01.1 (SPSS Inc., Chicago, Illinois). The Kolmogorov-Smirnov test was used to determine whether continuous variables were normally distributed. Skewed data were presented as medians and normally distributed data as means. Student’s t-tests were used for parametric data and Mann-Whitney U tests for non-parametric data to make compar-
isons between the two groups. The chi-squared test was used to make comparisons between the two groups for categorical variables. Statistical significance was set at $p < 0.05$.

**Results**

Over the nine-month recruitment period, 90 patients consented to take part in the study and were randomised into groups to receive either skin adhesive ($n = 45$) or staples ($n = 45$). In all, 12 patients were lost to follow-up because of non-attendance or cancellation of the three-month outpatient appointment. These patients have been seen subsequently with no reported adverse occurrences, but were not included in the final analysis as the time point for the last follow-up in the study was three months. Of the 78 remaining patients, one was excluded because of a fractured femur post-operatively, which required the wound to be re-opened for revision. Therefore, 77 patients were included in the analysis, 38 in the skin adhesive group and 39 in the staples group. All study participants were Caucasian and required THR for osteoarthritis. There was no statistically significant difference in the demographics between patients in the two groups (Table I). The mean age of the patients was 70 years (41 to 87); there were 51 women.

Follow-up appointments took place at a mean of 14.4 weeks (5.9 to 31.2) post-operatively, with no difference between the two groups for length of follow-up ($p = 0.203$). There were two cases of self-reported infection requiring antibiotics following discharge from hospital, one from the skin adhesive group and one from the staples group; both resolved with no further problems.

**Surgeon outcomes.** The orthopaedic and plastic surgeons’ scoring of the VAS for wound cosmesis showed no significant difference between the two methods of skin closure (Table II), although the plastic surgeon scored scars in both groups more highly than did the orthopaedic surgeon. There was no statistically significant difference between the methods of closure for any of the other assessment measures used by the plastic surgeon. All scars scored highly on the Hollander wound evaluation score 71 (92%).

<table>
<thead>
<tr>
<th>Table I. Patient demographics</th>
<th>Skin adhesive ($n = 38$)</th>
<th>Staples ($n = 39$)</th>
<th>$p$-value</th>
<th>All patients ($n = 77$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age in yrs (range)</td>
<td>71.4 (41 to 87)</td>
<td>68.2 (48 to 86)</td>
<td>0.151†</td>
<td>70 (41 to 87)</td>
</tr>
<tr>
<td>Gender (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male: Female</td>
<td>13:25 (34:66)</td>
<td>13:26 (32:67)</td>
<td>0.935†</td>
<td>66.2</td>
</tr>
<tr>
<td>Mean body mass index (range)</td>
<td>29.2 (20 to 46)</td>
<td>29.6 (22 to 40)</td>
<td>0.735†</td>
<td>29 (20 to 46)</td>
</tr>
<tr>
<td>Number of patients who have undergone surgery to other joints (%)</td>
<td>11 (29)</td>
<td>14 (36)</td>
<td>0.515†</td>
<td>25 (32)</td>
</tr>
</tbody>
</table>

* †-test
† chi-squared test

<table>
<thead>
<tr>
<th>Table II. Visual analogue scale (VAS) outcomes at three months</th>
<th>Skin adhesive ($n = 38$)</th>
<th>Staples ($n = 39$)</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median patient cosmesis VAS (range)</td>
<td>92.5 (42 to 100)</td>
<td>89 (37 to 100)</td>
<td>0.643†</td>
</tr>
<tr>
<td>Median patient satisfaction VAS (range)</td>
<td>96 (50 to 100)</td>
<td>95 (46 to 100)</td>
<td>0.422†</td>
</tr>
<tr>
<td>Mean orthopaedic surgeon cosmesis VAS (SD)</td>
<td>56.45 (15.07)</td>
<td>61.69 (15.97)</td>
<td>0.143†</td>
</tr>
<tr>
<td>Mean plastic surgeon cosmesis VAS (SD)</td>
<td>78.2 (10.93)</td>
<td>81.13 (7.35)</td>
<td>0.172†</td>
</tr>
</tbody>
</table>

* Mann-Whitney U-test
† t-test

<table>
<thead>
<tr>
<th>Table III. Modified Vancouver scar score</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skin adhesive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of patients (%)</td>
<td>1 (2.6)</td>
<td>3 (7.9)</td>
<td>0 (0)</td>
<td>14 (36.8)</td>
<td>9 (23.7)</td>
<td>11 (28.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Staples</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of patients (%)</td>
<td>4 (10.3)</td>
<td>4 (10.3)</td>
<td>1 (2.6)</td>
<td>17 (43.6)</td>
<td>6 (15.4)</td>
<td>7 (17.9)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of patients (%)</td>
<td>5 (6.5)</td>
<td>7 (9.1)</td>
<td>1 (1.3)</td>
<td>31 (40.3)</td>
<td>15 (19.5)</td>
<td>18 (23.4)</td>
<td>0 (0)</td>
</tr>
<tr>
<td>Between-groups $p = 0.452$ (chi-squared test)</td>
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of all scars were optimal, scoring 3 but six (8%) were considered sub-optimal with a score of 2), with no statistical difference found for the scores between groups (p = 0.083). The Vancouver scar score had similar distributions between groups for each score from 0 to 5 (Table III). Results for appearance on the Likert scale are shown in Figure 1.

Patient outcome. There was no statistically significant difference between the groups for patient cosmesis (p = 0.64), patient satisfaction (p = 0.42) or patient rating of the appearance of the wound compared to the expected appearance on a Likert scale (p = 0.94). Patients in both groups gave very high scores for both the cosmesis and satisfaction scales (Table III). Results for the Likert scale for expected outcome are shown in Figure 2.

A total of 15 patients in the skin adhesive group were pleased to have had adhesive rather than staples. One patient in the adhesive group stated a preference for staples from previous experience. Five patients in the staples group were disappointed not to have received skin adhesive.

Surgery outcomes. The mean length of incision was 17.7 cm (10 to 28). There was no significant difference in the length of the wound between the two groups (p = 0.64), or in the number of patients having a posterolateral or an anterolateral approach (p = 0.75). Skin closure with staples was faster than with skin adhesive. The mean time for closure with staples was 70.5 seconds (30 to 150), as opposed to a mean time for closure with the skin adhesive of 181.6 seconds (80 to 379). This difference between the two groups was statistically significant (p = 0.002). Surgeon-rated ease of use on the VAS also showed a statistically significant difference between the two groups (p = 0.005), with surgeons finding the staples easier to use than the skin adhesive. Of the six surgeons trained in the use of skin adhesive, one withdrew as he found the skin adhesive technically demanding. When asked at the end of the trial, of the five remaining surgeons, one strongly preferred staples as he felt they were a quicker method of closure, two weakly preferred the staples owing to the skin adhesive being more technically demanding, and two had no preference.

In-patient outcomes. At the in-patient assessment three to four days post-operatively, oozing was noted in 15 (39.5%) of the skin adhesive patients and 20 (51.3%) of the staples patients. This difference was not statistically significant (p = 0.30). One patient in the skin adhesive group was treated with oral antibiotics for a suspected wound infection which was not confirmed by the microbiological swab result. There were no cases of infection or of dehiscence.

Costs. The staples cost £3.67 for an applicator containing 35 staples. The skin adhesive costs £99.50 for a pack of five. Therefore, the cost to close a hip wound with staples was £3.67, plus £2.21 for the disposable staple remover, and with skin adhesive £19.90.

Discussion
This randomised trial showed no difference between the two methods of skin closure with regard to the cosmetic appearance of the scar, patient satisfaction, or complications three months after surgery. There was a significant difference for speed and ease of closure, staples being quicker and easier to use than the skin adhesive.

The primary outcome measure used was surgeon scoring of the cosmetic appearance of the scar at three months. The independent assessment of outcome by a plastic and an orthopaedic surgeon found no difference between skin adhesive and staples. There was no difference between the two groups for cosmetic outcome evaluated by the Hollander wound evaluation score and the Vancouver scar score at three months and this period has been shown to correlate strongly with scores at one year, therefore is likely to reflect long-term cosmetic outcome. These results
are in agreement with the study by Khan et al, who found there to be no difference in cosmetic appearance between skin adhesive, sutures or staples in hip and knee elective surgery. There was no difference between the groups for patient cosmesis, satisfaction or expected outcomes. All patient-based scores in both groups were high, showing patients prefer not to have staples taken out and so the adhesive was preferable. This has been mentioned in previous literature, with the removal of staples perceived as painful, but was not supported by our findings, which show both groups to be equally satisfied.

The most common complications of skin closure are wound infection and dehiscence. In our study, there was no difference in complication rates between the two groups. Because of the low infection rates in elective total joint replacement, a large sample size would be required to show any significant difference. The fact that during the inpatient stay there were no cases of infection or dehiscence in any patients involved in the study, and no difference between groups for presence of oozing, suggests that both methods of closure are safe and effective for use in THR. Similarly, although at the three-month follow-up there were self-reported cases of possible infection and one of the scar continuing to ooze, there was no significant difference between the two groups, indicating that both methods have an equally low likelihood of complications.

The only difference found between the two groups was for the surgical outcomes, speed and ease of closure, with the staples being quicker and easier to use than the skin adhesive, as surgeons felt skin adhesive to be more technically demanding. The mean skin closure time for skin adhesive was 110 seconds longer than that for staples. With regard to costs, skin adhesive is more expensive, and because closure takes longer would require fractionally more theatre time. The use of dressings and the amount of primary care follow-up required would also need to be taken into consideration. It is worth bearing in mind that wounds closed with skin adhesive would not incur the additional cost of the disposable staple remover and may also require fewer dressings, although this was not established in this study as patients in both groups were treated the same post-operatively. It has also been suggested that adhesive reduces the amount of follow-up required, as there is no need to attend for removal of the staples.

The results of this study suggest that both skin adhesive and surgical staples are effective methods of skin closure for THR. Further research could involve a more detailed cost analysis to determine the overall costs of each method.

References