Surface replacement conversion
RESULTS DEPEND UPON REASON FOR REVISION

Surface hip replacement (SHR) is generally used in younger, active patients as an alternative conventional total hip replacement in part because of the ability to preserve femoral bone. This major benefit of surface replacement will only hold true if revision procedures of SHRs are found to provide good clinical results.

A retrospective review of SHR revisions between 2007 and 2012 was presented, and the type of revision and aetiologies were recorded. There were 55 SHR revisions, of which 27 were in women. At a mean follow-up of 2.3 years (0.72 to 6.4), the mean post-operative Harris hip score (HHS) was 94.8 (66 to 100). Overall 23 were revised for mechanical reasons, nine for impingement, 13 for metallosis, nine for unexplained pain and one for sepsis. Of the type of revision surgery performed, 14 were femoral-only revisions; four were acetabular-only revisions, and 37 were complete revisions.

We did not find that clinical scores were significantly different between gender or different types of revisions. However, the mean post-operative HHS was significantly lower in patients revised for unexplained pain compared with patients revised for mechanical reasons (86.9 (66 to 100) versus 99 (96 to 100); p = 0.029). There were two re-revisions for infection in the entire cohort.

Based on the overall clinical results, we believe that revision of SHR can have good or excellent results and warrants a continued use of the procedure in selected patients. Close monitoring of these patients facilitates early intervention, as we believe that tissue damage may be related to the duration of an ongoing problem. There should be a low threshold to revise a surface replacement if there is component malposition, rising metal ion levels, or evidence of soft-tissue abnormalities.

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Surface hip replacement (SHR), or resurfacing of the hip, is an alternative to conventional total hip replacement (THR) in the treatment of end-stage arthritis, especially in younger, active patients. It was originally conceived in the 1970s but abandoned due to a high early failure rate. It was re-introduced in the 1990s when newly designed metal-on-metal bearings were anticipated to resolve the problem of osteolysis.

The goal of resurfacing is to maintain femoral bone stock in these younger patients, preserving more options for future revision surgery. A recent meeting of international hip surgeons in London also concluded that hip resurfacing likely provided better functional outcomes in younger, male patients. However, the benefit of SHR will only truly be realised in the long-term if revision can produce results equal to or better than those of revision THR. Because of this challenge, we sought to examine our results of revision of resurfacings with respect to patient factors, type of revision, and reason for revision.

Patients and Methods
All SHR revisions performed by the senior author (EPS) between 2007 and 2012 were included in our study. The primary SHRs were performed at a variety of institutions using several different implants. Patients were evaluated for symptoms referable to the operated hip, including pain, grinding, weakness, swelling, or limited range of movement. Work-up included clinical examination, bi-planar radiographs, metal ion analysis and cross-sectional imaging. Metal ion analysis was performed using high-resolution inductively coupled mass spectroscopy to measure serum levels of cobalt and chromium. The Agilent 7700x ICP-MS (Agilent Technologies, Santa Clara, CA) was used for measurement. Consistently high levels of cobalt or chromium (> 7 ppb) indicated a diagnosis of accelerated wear (metallosis).
Cross-sectional imaging included MRI with metal artifact suppression techniques, focused on evaluating the surrounding soft tissues.

Revisions were classified as femoral only, acetabular only, or both. Reason for revision was also ascertained pre-operatively and confirmed intra-operatively where possible. The aetiologies included infection, fracture of the femoral neck, collapse/osteonecrosis of the femoral head, implant loosening, impingement, accelerated wear/metallosis, metal sensitivity, and unexplained pain. Femoral-only revisions were performed when the acetabular component was in good position, found to be well-fixed at the time of surgery and with no evidence of excessive articular wear. An uncemented, stemmed implant was used with a metal femoral head that matched the existing acetabular component. An acetabular-only revision was performed in rare cases when there was evidence of acetabular malposition or impingement that could be corrected. In these cases, a monoblock, press-fit acetabular shell from the same implant manufacturer was used, matching the existing femoral head size. Full revisions consisted of an uncemented, stemmed femoral implant, and a press-fit acetabular component, with or without screws using ceramic-on-ceramic or ceramic-on-polyethylene articulations, with the largest head size available up to 36 mm in diameter.

Revision surgery was performed via a posterior approach with hypotensive epidural anaesthesia. Post-operatively, patients with full revisions were instructed to protect weight-bearing for six weeks and the femoral- or acetabular-only revisions were allowed to bear weight as tolerated. The excised tissues were sent for histological analysis and graded according the metal hypersensitivity scoring scale of Campbell et al.4 This is a numerical scale from 0 to 10, examining histologic features such as the appearance of the synovial lining, the type of inflammatory infiltrate, and tissue organisation. Scores are categorised as a low (0 to 5); moderate (5 to 8), and high (9 to 10) ALVAL score. All patients were required to use precautions to prevent dislocation for six weeks. Deep venous thrombosis prophylaxis with aspirin 325 mg orally twice a day was used for six weeks. Patients were followed clinically by examination and bi-planar radiographs and the Harris hip score (HHS)5 was assessed at six weeks, three months, and yearly post-operative visits.

**Technical aspects.** The surgical technique for surface replacement conversion is generally straightforward. If a femoral revision is planned, the head can be dislocated and the pre-operatively planned neck osteotomy measured. A cemented femoral implant can be removed from the bone by impacting it retrograde, which will facilitate neck osteotomy. Otherwise, a saw can be used to cut around the thin stem of the implant, and an osteotome used to complete the transection. Once the femoral head and neck have been shaped, the acetabular exposure is usually excellent. If the femoral head is to be maintained and an acetabular-only revision planned, then extensive capsular releases must be performed and the head will have to be tucked antero-superiorly relative to the acetabulum.

In order to remove the acetabular component, a large-ball adapter with curved osteotomes can be used (Innomed Inc., Savannah, Georgia). Alternatively, a trial acetabular liner with a known inner diameter can be used as a fulcrum for the Explant removal system (Zimmer Inc., Warsaw, Indiana) (Fig. 1). In general, the socket is not difficult to remove without excessive bone loss.

For patients with metallosis or metal sensitivity, an extensive synovectomy was performed, removing all visible foreign material. Osteolytic lesions were filled with bone autograft from the femoral head and neck, or cortico-cancellous allograft if necessary. A posterior capsular repair was performed with non-resorbable sutures in all patients.

**Statistical analysis.** This was performed using Microsoft Excel 2010 (Redmond, Washington). Student's t-test and chi-squared statistics were calculated with a significance level set at p < 0.05.

### Results

Surface replacement revisions were performed in 55 patients, of whom 27 were women. At a mean follow-up of 2.3 years (0.72 to 6.74), the mean post-operative HHS was 94.8 (66 to 100). Reasons for revision were grouped into the following categories: mechanical (including acetabular loosening, fracture of the femoral neck, collapse/loosening of the femoral head), infection, accelerated wear, impingement (including bone-to-implant and tendon-to-implant), and unexplained pain (including metal sensitivity). Overall 23 were revised for mechanical reasons; nine for impingement, 13 for metallosis, nine for unexplained pain, and one for deep infection. Of the type of revision surgery performed, 14 were femoral only revisions; four were cup-only revisions, and 37 were complete revisions (Table I, Fig. 2).
Analysis by revision type did not reveal any statistically significant difference in HHS regardless of whether the femur only, acetabulum only, or both components were revised. There was no statistically significant difference between male and female patients in terms of mean HHS (96.5 (80 to 100) and 92.7 (66 to 100), respectively; \( p = 0.10 \)). Analysis by reason for revision, however did demonstrate a difference based upon aetiology (Fig. 2). The mean HHS for mechanical aetiology of failure was the highest at 99 (96 to 100); followed by accelerated wear, at 96.4 (80 to 100); then impingement, at 90.4 (66 to 100); and lastly, the lowest mean HHS was 86.9 (66 to 100) for unexplained pain/metal sensitivity. There was no significant difference between HHS for the mechanical group and impingement (\( p = 0.083 \)), mechanical and accelerated wear (\( p = 0.18 \)), or accelerated wear and unexplained pain/metal sensitivity (\( p = 0.07 \)). However, there was a significant difference in HHS between a mechanical aetiology and unexplained pain/metal sensitivity (\( p = 0.029 \)). Four patients with unexplained pain had a histologically confirmed diagnosis of metal sensitivity as judged by an ALVAL score of five or greater, while the other five did not. There were no cases of dislocation, peri-prosthetic fracture, new implant loosening, deep venous thrombosis, or nerve palsy. There were two re-operations performed for infections at less than one year post conversion surgery.

Table I. Categories of reasons for surface replacement conversion, separated by gender

<table>
<thead>
<tr>
<th>Indication for revision (n, %)</th>
<th>All patients (n = 55)</th>
<th>Male (n = 28)</th>
<th>Female (n = 27)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanical</td>
<td>23 (42)</td>
<td>16 (57)</td>
<td>7 (26)</td>
</tr>
<tr>
<td>Impingement</td>
<td>9 (16)</td>
<td>8 (29)</td>
<td>1 (4)</td>
</tr>
<tr>
<td>Infection</td>
<td>1 (2)</td>
<td>1 (4)</td>
<td>0</td>
</tr>
<tr>
<td>Accelerated wear / metallosis</td>
<td>13 (24)</td>
<td>2 (7)</td>
<td>11 (41)</td>
</tr>
<tr>
<td>Unexplained pain / metal sensitivity</td>
<td>9 (16)</td>
<td>1 (4)</td>
<td>8 (30)</td>
</tr>
</tbody>
</table>

Discussion

We found in our series that the clinical results of revision surgery were dependent upon the reason for revision. Not unexpectedly, the results of surface replacement conversion are improved where the aetiology of the failure is clear. Femoral neck fracture and mechanical implant loosening can be recognised pre-operatively and a reliable solution provided, which is technically easy, and had excellent reproducible clinical scores. Our revisions for mechanical causes of failure such as fracture of the femoral neck or femoral head collapse were mainly femoral-only revisions, using a matching metal head to articulate with a well-fixed, well-positioned socket. However, in the current climate of evidence against using metal-on-metal THR\(^6\)\(^-\)\(^8\), this must be carefully considered with regard to causing future problems from corrosion products.

Impingement can typically be identified from pre-operative physical examination and radiographs\(^9\) and we found that it could be reliably solved with conversion surgery in our series with good clinical results. Accelerated wear as a cause of revision can be diagnosed with elevation in metal ion levels above what is expected for a well-functioning joint. Although excess metal debris can lead to pain and local tissue inflammation, we did not find any cases where there was massive necrosis of the soft tissues surrounding the joint. This may be a function of our close monitoring of patients with metal-on-metal hip resurfacings and, our routine use of metal ion testing allows us to identify patients at risk, thereby likely accelerating the time frame of their care and conversion surgery. Our threshold for revision of a SHR is low when components are mal-positioned and there is evidence of rising metal ion levels, or evidence of soft-tissue abnormalities on cross-sectional imaging.

We found that unexplained pain and metal sensitivity, categorised together, was the worst prognostic factor for clinical scores after revision surgery. Although we did not observe massive tissue damage that has led to poor results in other studies\(^10\)\(^-\)\(^12\) we suspect that ongoing inflammation from retained metal debris may be the culprit for continued problems.

The literature regarding surface replacement conversion is sparse. Ball, Le Duff and Amstutz\(^13\) examined their experience with femoral-only revisions and found clinical results comparable with that of a primary THR. This mirrors our results for mechanical failures. Grammatopolous et al\(^11\)
looked at revisions for pseudotumour, which includes both metal sensitivity and metallosis, and found poor results in a group of 16 patients with pseudotumour compared with revisions performed for femoral neck fracture. Of the patients having revision for pseudotumour, the clinical scores were significantly lower and the complication rate was higher (50% versus 14%). The authors describe complex revisions with massive soft-tissue destruction. Liddle et al.10 found poorer clinical results in patients undergoing revision surgery for hip resurfacing that failed due to solid pseudotumours. Our paper describes findings that patients with revision for unexplained pain and metal sensitivity associated with the cause of failure is related to the results of revision. Close monitoring of these patients is warranted to facilitate early intervention, as tissue damage may be related to the duration of an ongoing problem. There should be a low threshold to revise a surface replacement if there is component malposition, rising metal ion levels, or evidence of soft-tissue abnormalities.

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References