European validation of the Vancouver classification of peri-prosthetic proximal femoral fractures

F. Rayan,
M. Dodd,
F. S. Haddad

From University College London Hospital, London, England

Peri-prosthetic fractures after total hip replacement (THR) are difficult to manage. They are also becoming more common as primary THR is performed on an increasing number of younger, active patients and osteopenic elderly patients. As the average life expectancy increases, it is inevitable that there will be an increased risk of aseptic loosening and associated bone loss and an increased requirement for revision. The incidence of peri-prosthetic fracture can also be expected to rise. The Swedish National Joint Registry notes an incidence of peri-prosthetic fracture of 0.4% after primary THR and of 2.1% after revision.

A classification system for peri-prosthetic fractures has to be reliable and valid if it is to be a consistent guide to management. Various systems have been described, some of which depend on the site of the fracture, such as that of Parrish and Jones and Johansson et al, and others on the pattern of the fracture or the relationship to the stability of the implant. The classification system developed in Vancouver is simple and takes account of the stability of the femoral component and the state of the surrounding bone stock both of which are important in determining treatment. It divides the femur into three zones; A, B and C. Zone A is the proximal metaphysis, and fractures in this zone tend to involve the greater or lesser trochanter and do not extend into the diaphysis. Zone-B fractures involve the diaphyseal region but do not extend into the distal diaphysis. This zone is then further subdivided into B1, fractures with a stable implant (Fig. 1) B2, fractures with a loose implant (Fig. 2) and B3, fractures with a loose implant in the presence of severe loss of bone stock. Zone-C fractures occur in the distal diaphysis where the fracture is remote from the implant and can be treated relatively independently of the prosthesis (Table I). The reliability of any classification system is dependent on the consistency between different users (inter-observer), or the same user on different occasions (intra-observer), and the validity which assesses the degree to which the abnormality described in the classification actually represents the true abnormality. This is the only system which has been subjected to psychometric testing of its reliability and validity. An understanding of this system should enable an orthopaedic surgeon to construct a plan of management. We have re-validated this system independently in an alternative centre on a different continent.
Patients and Methods

We retrospectively analysed a cohort of 30 consecutive patients who had sustained a peri-prosthetic femoral fracture between May 2000 and February 2005. There were 12 men and 18 women with a mean age of 74.4 years (47.2 to 89.6). Only patients with a pre-operative radiological diagnosis and complete operative documentation of the type of fracture were included. Two patients had incomplete data and could not be included, which left 28 in the study. The fractures were classified pre-operatively according to the Vancouver system\textsuperscript{10,11,13} which was then verified at operation.

The bone quality before surgery was assessed from the radiographs using Paprosky’s classification\textsuperscript{14} of femoral defects. Definitive decisions about the type of reconstruction needed on the basis of the stability of the implant and the degree of bone loss were made per-operatively. The bone was considered to be adequate if good diaphyseal fixation could be achieved and poor if it was damaged or considered to be too thin to achieve this. The stability of the implant was assessed pre-operatively from the radiographs and confirmed at operation. If the implant was found to be stable fixation was undertaken, but if it was unstable the prosthesis was revised. No additional imaging was performed before surgery.

Before testing, all participants in the study were made familiar with the Vancouver classification. The radiographs of the 30 patients were reviewed by six consultant orthopaedic surgeons who undertook joint replacement surgery, six trainee surgeons and six medical students who had received no specialist training in this area, in order to assess intra- and interobserver reliability and reproducibility. Each observer examined the radiographs on two separate occasions and classified the fracture according to its type (A, B1, B2, B3 and C). The exercise was repeated after an interval of two weeks. Validity was tested on the radiological and operative findings of the B group of fractures by comparing the radiographs with the operative findings. Confirmation of pre-operative radiological classification was made at the operation by the surgeon and documented in the operative notes. Information about the quality of the bone and the stability of the implant for the B1 subgroup assessment was derived from the pre-operative radiographs.

Statistical analysis. The data were analysed using the weighted kappa statistic to measure the level of agreement for two observers, using the Landis and Koch\textsuperscript{15} criteria for interpretation. Values of 0.00 to 0.20 indicated slight agreement, 0.21 to 0.40 fair and 0.61 to 0.80 substantial agreement. Values of more than 0.80 indicated nearly perfect agreement.\textsuperscript{15} An independent statistician (JB) performed the statistical analysis.

Results

The interobserver agreement was 0.72 from the first reading and 0.74 from the second reading for the consultants, 0.68 and 0.70, respectively for the trainee sur-
Peri-prosthetic fractures are associated with a high rate of major complications including early mortality and considerable morbidity, and are expensive to treat.\textsuperscript{16,17} A standardised classification system and accepted treatment algorithms may minimise these problems, but the classification system adopted should be both reliable and valid thereby enabling selection of the most appropriate treatment for each case.\textsuperscript{11,13}

The Vancouver classification has gained worldwide acceptance with its logical analysis of the configuration of the fracture, the stability of the implant and the quality of the bone stock.\textsuperscript{18} However, its reliability and validity have previously only been tested by the originating group.\textsuperscript{13,19}

It is important to note that in a recent Swedish hip registry study, 80\% of the peri-prosthetic fractures were type B and difficulty was encountered in establishing the pre-operative diagnosis of type-B1 and type-B2 fractures.\textsuperscript{20} The high failure rate of treatment was attributed to the underdiagnosis of loose implants.\textsuperscript{20} To overcome this limitation, exploration of the joint and testing of the stability of the implant were recommended. The presence of struts and cables make it difficult to evaluate union of fracture, in these circumstances MRI and CT may be useful in pre-operative planning to assess the bone stock and to identify the pattern of the fracture. Post-operatively, these investigations may be helpful in confirming the degree of union both for the fracture itself and between allograft and the host bone when it has been required.\textsuperscript{21}

In our study, the pre-operative diagnosis determined by the classification of the radiographs, rarely changed at the time of surgery. This may be a reflection of our clinical practice in which all the peri-prosthetic fractures within our hospital are managed by the hip revision unit and both the bone stock and stability are assessed stringently during surgery. If the fracture had differed from that anticipated from the radiological assessment, long-stemmed revision implants and allograft bone were already available. For this reason CT was not routinely performed.

It can be difficult to determine the stability of a prosthesis and the quality of the bone stock pre-operatively. This is reflected by the kappa value for validity which was 0.67 for consultants within the B subgroup which, although representing substantial agreement, does not achieve the level of near-perfect agreement. For this reason we suggest that all peri-prosthetic fractures should be managed by surgeons with experience in revision surgery so that expertise in either stabilising the fracture or revising the femoral component is available at the time of surgery.

A rise in the incidence of peri-prosthetic fractures has previously been reported and, with an ageing population, is likely to continue.\textsuperscript{22} Spiralling health-care costs may force a decrease in the length of follow-up after a THR with the results that asymptomatic loosening is not identified at an early stage with an increase in risk of subsequent fracture.\textsuperscript{23}

Our results confirm the reliability and reproducibility of the Vancouver classification system. In addition, we have shown that substantial agreement can be found between individuals with no specialist training. This allows management to be planned early by less experienced surgeons, who may instigate early referral of appropriate cases to specialist centres. We also confirmed that this classification system is valid as there was substantial agreement with the operative findings. We accept that there will always be cases in which the establishment of a pre-operative diagnosis may be difficult. We therefore suggest that the management of peri-prosthetic fractures should ideally be carried out by experts in the field with the appropriate resources available to them.

Pre-operatively it is preferable to be able to classify a fracture and to decide exactly what the most appropriate surgical option should be since those with a stable pattern will require only simple reduction and fixation.

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Table I. Details of the Vancouver classification\textsuperscript{10}

<table>
<thead>
<tr>
<th>Type</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td></td>
</tr>
<tr>
<td>A(_1)</td>
<td>Lesser trochanter</td>
</tr>
<tr>
<td>A(_0)</td>
<td>Greater trochanter</td>
</tr>
<tr>
<td>B</td>
<td></td>
</tr>
<tr>
<td>B(_1)</td>
<td>Stable component</td>
</tr>
<tr>
<td>B(_2)</td>
<td>Unstable component</td>
</tr>
<tr>
<td>B(_3)</td>
<td>Unstable stem + poor bone quality</td>
</tr>
<tr>
<td>C</td>
<td></td>
</tr>
<tr>
<td>C(_G)</td>
<td>Greater trochanter</td>
</tr>
<tr>
<td>C(_A)</td>
<td>Lesser trochanter</td>
</tr>
</tbody>
</table>

Table II. Details of types of peri-prosthetic fractures

<table>
<thead>
<tr>
<th>Type</th>
<th>Radiological diagnosis</th>
<th>Peri-operative diagnosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>B(_1)</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>B(_2)</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>B(_3)</td>
<td>2</td>
<td>2</td>
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</tbody>
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in contrast to those with associated loosening of the component.  \(^{20,24,25}\)

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References