TRAUMA

Fixation of intracapsular fractures of the femoral neck in young patients

RISK FACTORS FOR FAILURE

The aim of this study was to determine the comorbid risk factors for failure in young patients who undergo fixation of a displaced fracture of the femoral neck. We identified from a prospective database all such patients ≤ 60 years of age treated with reduction and internal fixation. The main outcome measures were union, failure of fixation, nonunion and the development of avascular necrosis.

There were 122 patients in the study. Union occurred in 83 patients (68%) at a mean follow-up of 58 months (18 to 155). Complications occurred in 39 patients (32%) at a mean of 11 months (0.5 to 39). The rate of nonunion was 7.4% (n = 9) and of avascular necrosis was 11.5% (n = 14). Failures were more common in patients over 40 years of age (p = 0.03). Univariate analysis identified that delay in time to fixation (> 24 hours), alcohol excess and pre-existing renal, liver or respiratory disease were all predictive of failure (all p < 0.05). Of these, alcohol excess, renal disease and respiratory disease were most predictive of failure on multivariate analysis.

Younger patients with fractures of the femoral neck should be carefully evaluated for comorbidities that increase the risk of failure after reduction and fixation. In patients with a history of alcohol abuse, renal or respiratory disease, arthroplasty should be considered as an alternative treatment.

Younger patients constitute a small proportion of those presenting with fractures of the femoral neck, accounting for 3% of hip fractures.1-3 In older patients, the preferred treatment for a displaced femoral neck fracture is hemiarthroplasty or total hip replacement (THR) in the majority of cases.4-11 In younger patients, salvage of the femoral head is preferable and most surgeons consider early reduction and fixation as the treatment of choice.1,12-18 However, there is a risk of loss of fixation, nonunion or avascular necrosis (AVN).1,3,12,14-17,19-21 Previous studies have examined the outcome of femoral neck fracture fixation in relation to a variety of factors, and risk factors for a poor outcome include patient age, fracture displacement, time to fixation, anatomical reduction, method of reduction, and screw placement.1,3,14,16-18,21-24

There is limited data regarding the association between chronic comorbid conditions such as alcohol abuse, osteoporosis and steroid therapy on the outcome following fixation of femoral neck fractures in young patients.12 The aim of this study was to determine the prevalence of comorbid conditions in young patients undergoing hip fracture fixation and the association between such comorbidities and outcome.

Patients and Methods

From our prospective trauma database we identified all patients ≤ 60 years of age who sustained a displaced (Garden type III or IV25) intracapsular fracture of the femoral neck. Patients who underwent reduction and fixation by cannulated screws were included in the study. Patients presenting more than one week from injury were excluded. Using these criteria 152 patients were identified over a 13-year period from December 1995 to June 2008. A total of 30 were lost to follow-up, four of whom died within 18 months of surgery, leaving 122 patients in the study. There were 58 men and 64 women with a mean age of 49 years (17 to 60). We recorded demographic data including treatment, time to fixation, the grade of the operating surgeon, type of reduction (open/closed), complications and requirement for revision surgery. All potential predisposing factors including chronic medical comorbidities, medications, alcohol excess and smoking were noted. Alcohol excess was defined as units in excess of current National Health Service recommendations (for female patients no more than 2 to 3 units per day and 14 units per week, and for males 3 to 4 units per day and 21 units...
was satisfactory on both anteroposterior (AP) and lateral radiographs (Fig. 1). 27,28 On the AP view the angle used was that which subtends the central axis of the medial trabecular system in the head and the medial cortex of the femur. On the lateral view the angle used was that of the central trabecular axis in the head and the line of the femoral neck. An angle of between 160° to 180° was deemed satisfactory on both views.

All patients were treated with reduction and fixation using three cannulated screws. Our preferred technique was parallel placement of three screws in the superior, central and inferior position on an AP view, with parallel screw placement on the lateral view, in the central or posterior aspect of the head. An open reduction was used when our preferred closed technique did not achieve a satisfactory reduction. Aspiration of the haemarthrosis was not routinely performed. Following the operation patients were mobilised and advised to touch weight-bear for six weeks and fully weight-bear thereafter.

Adequate follow-up was defined as documented review at ≥ 18 months following surgery, using a combination of clinical and/or radiological assessment, but both were not required. All patients were reviewed at our institution, which is the sole provider of orthopaedic care in the region. We aimed to keep patients under review for at least two years following surgery.

The main outcome measures were union, failure of fixation, nonunion and the development of AVN. Union was defined as an asymptomatic patient with radiological evidence of bone bridging across the fracture and re-establishment of trabecular pattern on AP and lateral radiographs. Failure of fixation was defined as early redisplacement of the fracture and the screws (Fig. 2). Nonunion was defined as pain and radiological evidence of nonunion six months after surgery. Failure due to AVN was defined as radiological evidence of subchondral sclerosis or segmental collapse (Fig. 3).

**Statistical analysis.** SPSS Version 17.0 (SPSS Inc., Chicago, Illinois) was used for the statistical analysis. A Student’s unpaired t-test was used to analyse parametric continuous

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Fig. 1

Drawings showing the Garden alignment index, with an angle of 160° to 180° on both anteroposterior and lateral radiographs considered satisfactory. 27 The black arrows indicate anatomical reduction, with the red arrows representing unacceptable reduction positions (picture reproduced from Keating JP. Femoral neck fractures. In: Bucholz RW, Court-Brown CM, Heckman JD, Tornetta P, eds. Rockwood and Green’s fractures in adults. Seventh ed. Philadelphia: Lippincott Williams & Wilkins, 2010).

Fig. 2

Anteroposterior radiograph of the pelvis showing loss of fixation with displacement of the screws.

Fig. 3

An MRI scan of the pelvis showing failure due to osteonecrosis of the right femoral head, subchondral sclerosis and segmental collapse.
data. Categorical binary data were analysed using either the chi-squared test \((n > 5)\) or Fisher’s exact test \((n \leq 5)\).

Variables were examined using univariate analysis to determine predictors of failure. Factors found to be significant or near-significant \((p < 0.10)\) on univariate analysis were incorporated and underwent multivariate binary logistic regression analysis to determine independent predictors of failure. Age, gender, alcohol excess, smoking, pre-injury mobility, comorbidities (chronic respiratory disease, diabetes, pre-existing renal failure, liver disease, epilepsy, cerebral palsy, learning difficulties), medications (steroids, anti-epileptics), time to fixation, grade of the operating surgeon and the quality of the reduction were

the variables examined. Significance was determined as a p-value of < 0.05 in all analyses.

Results

Of the 122 patients, the mean age of the women (52 years, 33 to 60) was significantly higher than that of the males (45 years, 17 to 60) at the time of injury \((p < 0.001)\). Over 85% \((104)\) of the patients were between the ages of 40 to 60 years (Fig. 4). The most common mechanism of injury was a fall from standing height in 103 patients \((84\%)\). High energy injuries (fall from height, road traffic accident) were more frequently seen \((8 of 18, 44\%)\) in patients under the age of 40 years (Fig. 5).

Union occurred in 83 patients \((68\%)\) at a mean of 58 months \((18 to 155)\). Complications occurred in 39 patients \((32\%)\) at a mean of 11 months \((0.5 to 39)\), with loss of fixation the earliest and most common cause for failure (Table I). The rate of nonunion was 7.4\% \((n = 9)\) and the rate of AVN was 11.5\% \((n = 14)\). AVN took a mean time of 19.8 months \((6 to 39)\) to develop.

Of the 39 patients with complications, 18 underwent primary revision to a cemented THR, one of whom underwent a further revision because of recurrent dislocation and another had an excision arthroplasty for infection. There were nine patients who underwent revision to a primary cemented bipolar hemiarthroplasty, one of whom was subsequently revised to a THR and another to an excision arthroplasty for infection. In all, eight patients underwent screw removal, with five subsequently undergoing secondary revision, three to a THR and two to a cemented bipolar hemiarthroplasty. Four patients (three AVN, one nonunion) elected to undergo no further surgery.

Of these 39 patients, predisposing causes for failure were found in 30 \((77\%)\). No difference in age was seen between the non-failure and failure group \((p = 0.26)\), with no gender predominance observed \((p = 0.57)\). However, failure was more frequently seen in patients aged between 40 and 60 years \((37 of 104, 36\%)\) than those under 40 years \((two of 18, 11\%)\) \((p = 0.03)\).

A background of alcohol excess was most predictive of failure on univariate analysis \((p < 0.001)\), with mobility requiring aids prior to injury approaching significance \((p = 0.08)\). Smoking was not associated with an increased risk of failure \((p = 0.35)\). Pre-existing renal failure \((p = 0.03)\), respiratory disease \((p = 0.03)\) and liver failure \((p = 0.04)\) were also predictive of failure and cerebral palsy was approaching significance \((p = 0.08)\). Carbamazepine was the only drug approaching significance as a predictor of failure \((p = 0.08)\), with four of
39 (10%) affected in the failure group, compared with two of 83 (2%) in the non-failure group. Steroid therapy was not predictive of failure ($p = 0.68$; Table II).

There were 39 patients (32%) with post-reduction radiographs available for review, of whom 12 went on to fail. Whether analysed in isolation or in combination, AP and lateral malreduction were not predictive of failure (Table III).

Of the peri-operative factors, delay in time to fixation was the only predictive factor ($p = 0.005$) with no association seen with the type of reduction ($p = 0.539$) or the grade of the surgeon ($p = 0.43$). On multiple regression analysis alcohol excess, renal disease and respiratory disease were the only factors predictive of failure (Table IV).

**Discussion**

A union rate approaching 70% and a failure rate of just over 30% following hip fracture fixation in young patients is comparable with existing data.$^{1,16,17,19}$ We found that pre-existing renal failure, respiratory disease and alcohol

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**Table II.** The demographics and risk factors for all patients categorised by failure

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>No failure</th>
<th>Failure</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (%)</td>
<td>83 (68)</td>
<td>39 (32)</td>
<td>N/A†</td>
</tr>
<tr>
<td>Males:females (M:F ratio)</td>
<td>38:45 (1:1.2)</td>
<td>20:19 (1:1)</td>
<td>0.57‡</td>
</tr>
<tr>
<td>Mean age (range)</td>
<td>48.0 (17 to 60)</td>
<td>50.2 (23 to 60)</td>
<td>0.26§</td>
</tr>
<tr>
<td>Males</td>
<td>43.3 (17 to 60)</td>
<td>48.9 (23 to 59)</td>
<td>0.10¶</td>
</tr>
<tr>
<td>Females</td>
<td>51.9 (33 to 60)</td>
<td>51.6 (40 to 60)</td>
<td>0.86¶</td>
</tr>
<tr>
<td>Smoking (%)</td>
<td>19 (23)</td>
<td>12 (31)</td>
<td>0.35§</td>
</tr>
<tr>
<td>Alcohol excess (%)</td>
<td>9 (11)</td>
<td>14 (36)</td>
<td>&lt; 0.001‡</td>
</tr>
<tr>
<td>Pre-existing mobility problems (%)</td>
<td>2 (1)</td>
<td>4 (10)</td>
<td>0.08</td>
</tr>
</tbody>
</table>

**Comorbidities (%):**

- Chronic respiratory disease: 3 (4) vs. 5 (13), $p = 0.03$
- Diabetes: 3 (4) vs. 2 (5), $p = 0.65$
- Renal failure: 0 (0) vs. 3 (8), $p = 0.03$
- Liver disease: 1 (3) vs. 4 (10), $p = 0.04$
- Epilepsy: 6 (7) vs. 5 (13), 0.31‡
- Cerebral palsy: 2 (2) vs. 4 (10), $p = 0.08$
- Learning difficulties: 9 (11) vs. 9 (23), 0.07¶
- Eating disorders: 0 (0) vs. 1 (3), 0.32

**Drugs (%):**

- Anti-epileptics: 6 (7) vs. 4 (10), $p = 0.72$
- Steroids: 4 (5) vs. 3 (8), $p = 0.68$

<table>
<thead>
<tr>
<th>Delay in time to fixation (&gt; 24 hours) (%)</th>
<th>No failure</th>
<th>Failure</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 (22)</td>
<td>18 (46)</td>
<td>0.005‡</td>
<td></td>
</tr>
<tr>
<td>Open reduction (%)</td>
<td>1 (1)</td>
<td>1 (3)</td>
<td>0.539</td>
</tr>
</tbody>
</table>

* Fisher’s exact test unless otherwise stated
† N/A, not applicable
‡ Chi-squared test
§ Unpaired $t$-test

**Table III.** Results of univariate analysis determining whether radiological malreduction was predictive of failure in 39 patients with available radiographs

<table>
<thead>
<tr>
<th>Reduction (%)</th>
<th>No failure</th>
<th>Failure</th>
<th>$p$-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total (%)</td>
<td>27 (69)</td>
<td>12 (31)</td>
<td>N/A†</td>
</tr>
<tr>
<td>AP$^\dagger$ malreduction</td>
<td>3 (11)</td>
<td>3 (25)</td>
<td>0.28</td>
</tr>
<tr>
<td>Lateral malreduction</td>
<td>4 (15)</td>
<td>2 (17)</td>
<td>0.61</td>
</tr>
<tr>
<td>AP or lateral malreduction</td>
<td>6 (22)</td>
<td>4 (33)</td>
<td>0.36</td>
</tr>
<tr>
<td>AP and lateral malreduction</td>
<td>1 (3)</td>
<td>1 (8)</td>
<td>0.53</td>
</tr>
</tbody>
</table>

* Fisher’s exact test
† N/A, not applicable
‡ AP, anteroposterior
abuse were the comorbidities most strongly predictive for failure following fixation of a hip fracture in young adults. These three risk factors predispose to poor bone quality and so these patients are often poor candidates for internal fixation.\(^1,27,29-31\) Some studies have alluded to medical comorbidities such as these, but none have analysed the relationship in detail.\(^12\)

Interestingly, steroid therapy was not predictive of a poor outcome in our patients, although chronic respiratory disease was significant. This may be related to the combination of long-term steroid use and respiratory disease being associated with osteoporosis.\(^12,33\) Anti-epileptic medications are associated with reduced bone mineral density. In the present study carbamazepine was the only medication approaching significance as predictive for failure following femoral neck fracture fixation.\(^34\)

The duration of time from injury to fixation of a femoral neck fracture is often considered important.\(^35\) The lack of a clear relationship between timing of surgery and complications has been noted in other series, with similar findings reported in a recent meta-analysis.\(^16,17,21\) It is probable that the degree of damage to the vascularity of the femoral head is determined at the time of the initial injury, with early reduction and fixation having no effect on this.\(^14\) However, others argue that early reduction, within 8 to 12 hours, reduces the risk of complications, in particular AVN.\(^12,18,22\)

Although time to fixation was significantly associated with failure of fixation on univariate analysis, multivariate analysis indicated that medical comorbidities were more strongly predictive of failure. We do not routinely perform an open reduction given that existing data show no difference in outcome when compared to closed reduction, with possibly a higher rate of nonunion.\(^17,21\) The importance of an anatomical reduction has been clearly shown in the literature, with increased rates of complications seen when this is not achieved, particularly following a varus reduction.\(^36\) However, we found no relationship between malreduction and failure. Undoubtedly a limitation of the analysis was the number of post-operative radiographs available. This was due to a policy of culling radiographs older than five years in patients not under regular review. Clearly with a larger number of radiographs, a significant correlation with quality of reduction might have been shown. Although the grade of the operating surgeon varied, we found no correlation between the experience of the primary surgeon and failure.

Other studies have reported the outcome of fixation of femoral neck fractures in younger patients in relation to factors such as time to fixation, but none have incorporated medical comorbidities with their analysis. The present study shows young patients with comorbid risk factors, particularly those associated with poor bone quality, should undergo careful pre-operative evaluation and be advised with regards to their increased risk of failure following hip fracture fixation. For patients under 40 years of age with a displaced femoral neck fracture, irrespective of associated risk factors, we would recommend early reduction and fixation given the lower risk of failure in these patients. For patients between 40 and 60 years of age with associated risk factors for poor bone quality and failure, we now consider a THR depending on pre-morbid mobility and cognitive status. For patients between 40 and 60 years of age with a background of alcohol abuse, a bipolar hemiarthroplasty might be safer than a THR to minimise the risk of dislocation associated with alcohol withdrawal or subsequent episodes of intoxication.\(^27\)

The main strength of their study is that it represents a large series of young patients undergoing fixation for displaced femoral neck fractures, with prospective data collection. Our loss to follow-up rate of 20% is a limitation but probably reflects this younger more mobile patient population. However, as we are the only local centre providing a musculoskeletal trauma service, it can be argued that most of these patients did not re-attend as they were asymptomatic. Although this is one of the largest series of displaced femoral neck fractures, with a larger number of patients some factors such as time to fixation may have proved significant on multivariate analysis.

Damany et al\(^21\) performed a recent meta-analysis which estimated that the overall rate of nonunion was 8.9% following fixation in young (≤ 50 years) hip fracture patients, with a rate of AVN of 23%. Our nonunion rate of 7% is close to this as well as other published data.\(^1,14,16,37\) The rate of AVN seen in our patients is lower than that found by Damany et al,\(^21\) although the figures for this complication in the literature vary more widely, ranging from 0% to 86%.\(^3,38\) Our study found a significantly lower mean age in males when compared with females for displaced femoral neck fractures in young adults, with high energy trauma frequently seen in patients under the age of 40 years.\(^1,12\) These findings, in conjunction with the fact that approximately 85% of our fractures were seen in patients over the age of 40 years following a low energy fall,\(^1\) suggest that the vast majority of these injuries are fragility fractures associated with poor bone quality.\(^12\) Furthermore, we have shown that over 80% of these patients have significant comorbidities such as alcohol excess, that not only predispose to a hip fracture, but also are associated with a poor

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**Table IV. Results of multivariate binary regression analysis performed to determine significant predictors of failure following hip fracture fixation in young patients**

<table>
<thead>
<tr>
<th>Variable</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alcohol excess</td>
<td>0.001</td>
</tr>
<tr>
<td>Pre-existing mobility problems</td>
<td>0.435</td>
</tr>
<tr>
<td>Chronic respiratory disease</td>
<td>0.019</td>
</tr>
<tr>
<td>Renal failure</td>
<td>0.020</td>
</tr>
<tr>
<td>Liver disease</td>
<td>0.217</td>
</tr>
<tr>
<td>Cerebral palsy</td>
<td>0.064</td>
</tr>
<tr>
<td>Learning difficulties</td>
<td>0.556</td>
</tr>
<tr>
<td>Carbamazepine</td>
<td>0.133</td>
</tr>
<tr>
<td>Time to operation &gt; 24 hours</td>
<td>0.081</td>
</tr>
</tbody>
</table>
outcome. Dual-energy X-ray absorptiometry (DXA) would provide a more comprehensive assessment of bone quality. However, these younger patients present acutely, and the success of reduction and fixation can be time-dependent. Pre-operative screening with DXA is impractical in an emergency setting. Future investigation with these patients utilising DXA post-operatively may be useful.

In conclusion, these findings indicate that medical comorbidities are strongly predictive of failure of fixation after displaced femoral neck fractures in younger patients. Based on our findings we recommend arthroplasty be considered as an alternative to fixation, particularly where there is a history of alcohol excess, renal disease or respiratory disease. This particularly applies to the patients over the age of 40 years who are at increased risk of failure.

References