



Internal fixation of fractures of the proximal humerus with a humeral fixator plate (PlantTan Plate) : A two year follow-up

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Fractures of the proximal humerus are common. Most can be treated conservatively with good results. However, there is no uniform treatment of displaced fractures.

One option was the PlantTan Plate (PTP). We present a study of 65 patients with displaced proximal humeral fractures treated with the PTP. Patients were followed-up for 24 months assessing fracture healing, functional outcome, pain and postoperative complications. The mean patient age was 61 years (range : 17 to 86). Forty-six percent of the patients were aged over 65 years. The Constant-Murley shoulder score (CMS) to assess function and a visual analogue scale (VAS) assessing pain were used. At 24 months, the mean CMS was 76 (range : 34 to 100) for the fractured side and 85 (range : 66 to 100) for the uninjured side, the mean VAS was 22 (range : 0 to 78). We believe that this study shows that operative intervention is a viable option for displaced proximal humeral fractures.

Keywords : proximal humerus ; fracture ; plate fixation.

INTRODUCTION

Fractures of the proximal humerus represent 4% to 5% of all fractures attended to by accident and emergency or orthopaedic departments (13,15). In the young and middle-aged, these fractures usually occur due to high-energy trauma, however in the elderly, they are often related to osteoporosis (20). Indeed, it has been shown that there has been an

increase in the incidence of proximal humeral fractures in the elderly over the last 50 years and that these types of fractures are roughly half as common as hip fractures (8,10).

Neer classified these fractures as displaced if any of the four parts of the proximal humerus (the humeral head, shaft, greater tuberosity, lesser tuberosity) are displaced more than 1cm or are angulated more than 45° (19) (figs 1 & 2). Those fractures that are not displaced or angulated by these parameters are grouped together as undisplaced, regardless of the number of fragments, in Neer's classification (19).

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Fig. 1. — AP radiograph of a right proximal humeral fracture in an octogenarian with severe valgus impaction.



Fig. 2. — Lateral radiograph of same patient as fig 1.

Undisplaced proximal humeral fractures usually have an intact capsule and rotator cuff and thus have intrinsic stability. Undisplaced two-part fractures of the proximal humerus are the most common and may be treated conservatively, with good results (2, 17,19).

For displaced proximal humeral fractures no treatment has been proven to be ideal. Three and four-part fractures represent 13% to 16% of all proximal humeral fractures (21). Treatment options for such fractures range from conservative management or closed reduction and minimal osteosynthesis with K-wires, to open reduction internal fixation with plates or in extreme circumstances arthroplasty (15). This multiplicity of variable options and the lack of a suitable implant made various authors advocate conservative treatment even in displaced

2-part fractures of the surgical neck of the humerus (9). Most authors do however accept that displaced fractures of the proximal humerus should be treated surgically (3,14). One such implant developed for the use of internal fixation of proximal humeral fractures was the PlantTan Plate (Medizintechnik GmbH, Aachen, Germany).

The PlantTan Plate (PTP) was designed to provide both angular and rotational stability to proximal humeral fractures (figs 3 & 4) and became available for clinical use approximately eight years ago. It aimed to allow an effective means of fixing these fractures providing adequate stability, allowing early mobilisation and thus early return of shoulder function. It was unique in that it also provided a means of reattaching the tuberosities and therefore allowed simple reconstruction of the soft



Fig. 3. — AP radiograph of same patient seen in figs 1 & 2, three months following ORIF with a PTP.



Fig. 4. — Lateral radiograph of same patient as in figs 1 & 2, three months following ORIF with a PTP.

tissue envelope. Since the introduction of the PTP a number of other locking plate devices designed for use in proximal humeral fractures have been developed such as the PHILOS plate (Synthes, Switzerland) reported on by Bjorkenheim *et al* (4).

This paper presents a longitudinal observational study of patients treated using a PTP. The aim has been to assess fracture healing, functional outcome, pain and postoperative complications. Patients have been followed-up until two years post surgery.

PATIENTS AND METHODS

All patients treated by the primary shoulder surgeon in four orthopaedic units in the Northwest of England (The Royal Oldham Hospital, The Royal Preston Hospital, The Royal Bolton Hospital and North Manchester General Hospital) with displaced Neer classified proximal humeral fractures requiring surgery between March 2000 and April 2003 were treated with a PTP. The need for surgical intervention was decided by the consultant shoulder surgeon after consideration of

the clinical and radiological evidence. All patients undergoing surgery with the PTP were included.

Data was collected prospectively predominantly by the first author (MS) but also by three of the co-researchers (LB, JSB and SK) in MS's absence.

Patients were seen at 2, 6, 12 and 24 months following surgery and examined clinically and radiologically at each visit. At the same time, patients also completed a visual analogue score (VAS) to assess pain (1). The VAS was a linear scale from 1 to 100 repeated 3 times on each occasion. The Constant-Murley clinical method of functional assessment of the shoulder was used to assess shoulder function (7). The Constant-Murley Score (CMS) was obtained for both the injured and the non-injured shoulder at each stage. The range of active motion was measured using a goniometer. Painless flexion, abduction, external and internal rotation were measured. The power assessment was undertaken using the Nottingham McMeisin Myometer™.

Table I. — Break down of patients included in the study

	2-part fracture	3-part fracture	4-part fracture
No. of patients (% total)	26 (40%)	30 (46%)	9 (14%)
Mean age	66 years	58 years	60 years
No. of patients < 65 years (% total)	10 (15%)	19 (29%)	6 (1%)
Mean age of patients < 65 years	49 years	32 years	53 years
No. patients > 65 years (% total)	16 (25%)	11 (17%)	3 (5%)
Mean age of patients > 65 years	78 years	73 years	73 years

The SF-36 health evaluation questionnaire (24) was completed by each patient upon presentation (prior to operation) and then at the 1 year and 2 year marks.

Two-view (anteroposterior and lateral) radiographs were used to identify union (cortical bridging on 3 or more cortices on 2 views), malunion and avascular necrosis (AVN). Radiographs were taken at each review until union was confirmed and then a final set of radiographs were taken at the 2 year review to determine AVN rates.

Full research and ethics approval was obtained (Ref : 2002.1.vi). Data was inputted into an Excel spreadsheet (Microsoft corp. 2000) and statistical analysis was undertaken by the HR&DNoW based at Department of Mathematics and Statistics at Lancaster University (researcher AD) using the SPSS13 statistical package.

RESULTS

Sixty eight consecutive patients with displaced 2-, 3- and 4-part proximal humeral fractures were treated by open reduction and internal fixation with a PTP. Two patients declined to consent to be included in the study and one patient moved out of the area without providing future contact details and thus was censored from follow-up. Therefore a total of 65 patients with acute fractures were prospectively followed to the 2 year mark. The overall mean patient age was 61 years (range : 17 to 86). Twenty two (34%) patients were male and 43 (66%) were female. The breakdown for the fracture type and group can be seen in table I. Thirty six (55%) of the fractures involved the patient's domi-

nant arm and the remaining 29 (45%) involved the non-dominant side.

At 2 months post-surgery the mean CMS was 46 (range : 11 to 82) on the fractured shoulder compared to 86 (range : 58 to 100) for the uninjured side, and the mean VAS was 32 (range : 3 to 82). At 6 months post-surgery the mean CMS was 62 (range : 28 to 100) on the fractured shoulder compared to 85 (range : 46 to 100) for the uninjured side and the mean VAS was 25 (range : 1 to 85). At 12 months, the mean CMS was 72 (range : 28 to 93) for the fractured side, compared to 87 (range : 66 to 100) for the uninjured side, with a mean VAS of 21 (range : 2 to 53). At 24 months, the mean CMS was 76 (range : 34 to 100) for the fractured side, compared to 85 (range : 66 to 100) for the non-fractured side, with a mean VAS of 22 (range : 0 to 78) (figs 5-7). The mean pre-op SF-36 score was 75 (range : 27 to 100), at one year the mean was 72 (range : 32 to 100) and at 2 years the mean SF-36 score was 76 (range : 23 to 100). Further analysis has been undertaken comparing results for the different fracture types and for those patients under the age of 65 and those over the age of 65 at time of operation for each outcome measure.

Figure 8 shows the box and whisker plots for the CMS of the fractured side for each fracture pattern and for the over and under 65's. The CMS for the injured shoulder in both the young and the old in all three fracture groups improved with time over the 2 year period. There is a trend for the under 65's to improve quicker in the initial post operative period,

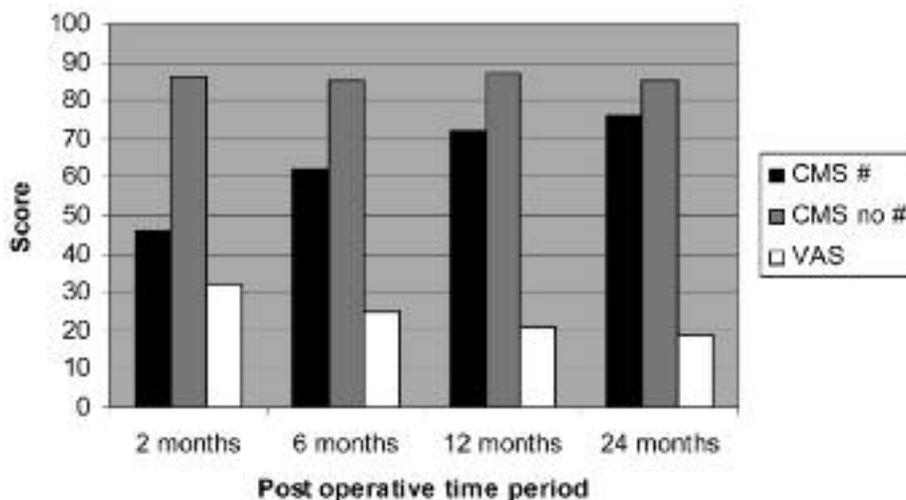


Fig. 5. — Mean Constant Murley Score and VAS for the whole group, at 2, 6, 12 and 24 months post-surgery

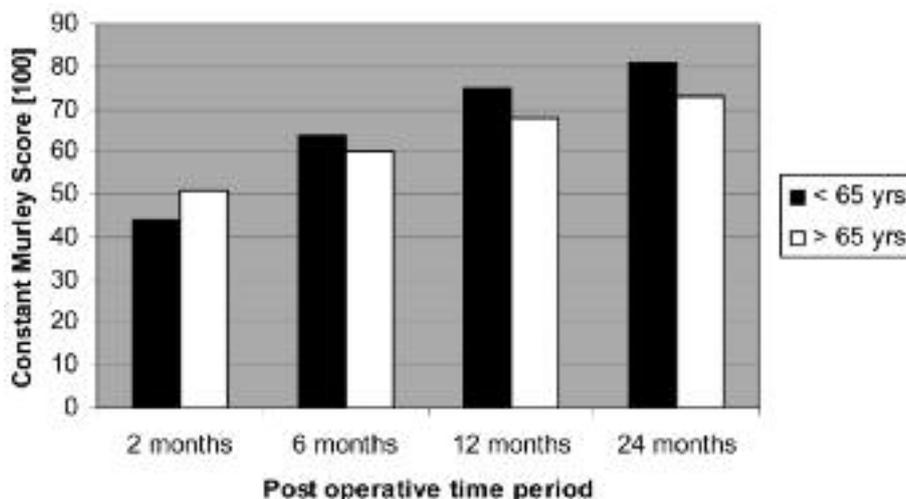


Fig. 6. — Difference in mean Constant Murley score between the injured and non-injured shoulders for the over 65's and the under 65's.

but the over 65's catch up by the 2 year point. This initial trend does not reach statistical significance and there is no difference between the fracture types. At the 2 year point there is still a significant difference between the function of the injured shoulders compared to the uninjured side for all 3 fracture groups ($p < 0.001$, Wilcoxon signed rank test). It was noted that there was a difference in the CMS of the non-injured side for those under 65 compared to those over 65 ($p < 0.031$, Mann

Witney U test), so the CMS of the injured shoulders were standardised with respect to the CMS of the uninjured shoulders. The standardised CMS for the injured shoulders of the two age groups was compared using a Mann Whitney U test which showed that there was no statistical difference in CMS of the injured shoulders for all 3 fracture groups ($p = 0.946$, 12 months, $p = 0.982$, 24 months).

Figure 9 shows a box and whisker plots for the VAS of the injured shoulder for each fracture group

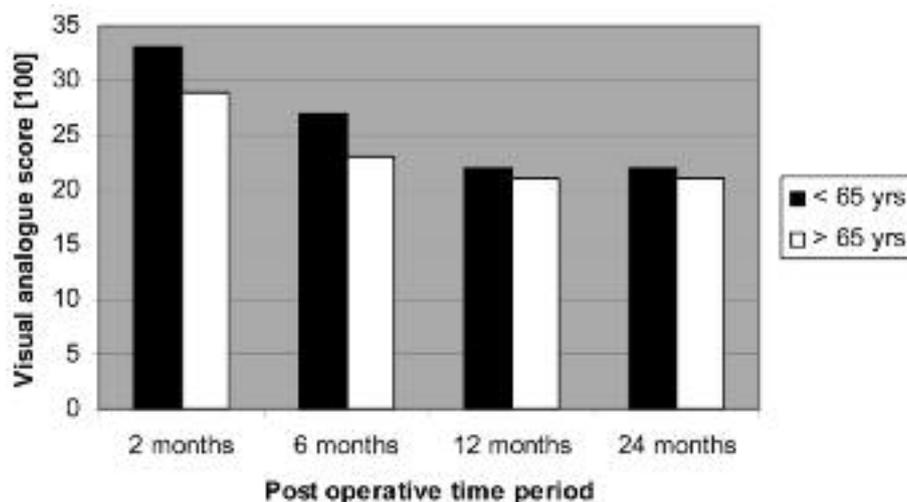


Fig. 7. — Mean VAS scores (out of 100) at 2, 6, 12 and 24 months for the over 65's and the under 65's

and for the over and under 65's. It can be seen that the different fracture groups tended to respond slightly differently to the pain. The over 65's with 2 part fractures tended to have less pain overall than the under 65's with 2 part fractures. Those patients with 3 part fractures had similar pain levels whether over or under 65 years old whereas the elderly patients with 4 part fractures tended to experience more pain than the younger patients with 4 part fractures. These differences, within the fracture groups, do however only represent trends and Mann Whitney U tests have not revealed any statistically significant difference ($p > 0.25$).

Figure 10 shows the box and whisker plots for the SF-36 scores for each fracture type and for the over and under 65's. The 2-part fracture group seem to have lower SF-36 scores at 2 years especially for the over 65's. The 3-part fracture group have fairly uniform scores for the under 65's but the over 65's in this group tend to have reduced scores compared to pre-op at 1 year, however this has recovered to scores higher than pre-op at the 2 year review. The 4-part fracture group shows the SF-36 score to improve steadily for the under 65's, indeed at 2 years the scores are higher than pre-op with the over 65's responding the same as the over 65's with

3-part fractures. Again these represent trends only with Kruskal Wallis test revealing no significant difference between the ages within the groups at a 5% significance level. Additionally Mann Whitney U test revealed no difference between the groups at a 5% significance level.

At 2 months 2 patients had died, at 6 months a further two patients had died and 1 more had died by 12 months. All of these deaths have been confirmed by the coroner to be due to unrelated causes. At 2 months 7 had failed to continue to attend follow-up leaving 56 under continued review, a further patient had dropped out of follow-up by 6 months and a further patient had dropped out by 12 months leaving a total of 54 patients under review at 1 year. An additional 2 failed to attend final review at 2 years resulting in 52 patients being fully followed to the 2 year point. No assumptions have been made regarding the clinical outcome of those not attending for further review.

The average length of hospital stay was 10 days with the average time post-PTP surgery being 6 days. Twenty six out of 56 (46%) patients followed-up at 2 months had united proximal humeral fractures. At 6 months 51 out of 55 (93%) patients seen had united fractures, at 12 months 54 patients

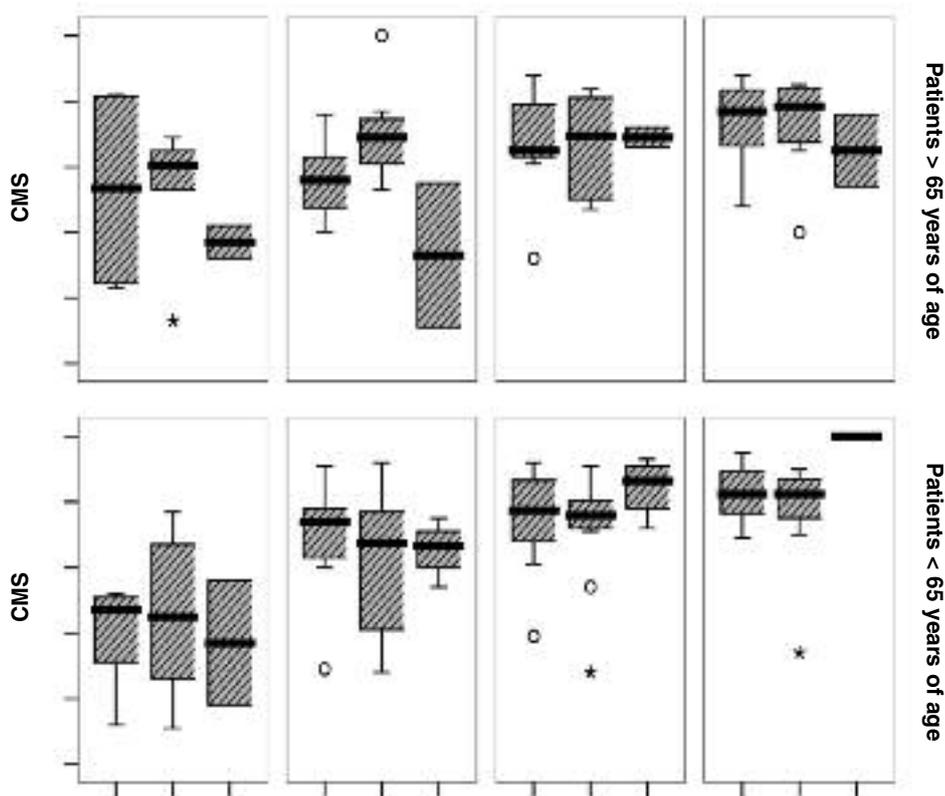


Fig. 8. — Box and Whisker plots for the Constant Murley score of the fractured side for each fracture pattern and for the over and under 65's.

out of 54 (100%) seen had united fractures. At the final check-up at 24 months, 100% (52 patients) seen had united fractures.

Complications were as follows : radiographically screws have backed out in 4 (6%) patients. One patient had a screw removed 4 months post-operatively and then went on to have the plate removed 11 months after insertion for persistent pain due to impingement. The second patient went on to have the plate and screws removed at 4 months post insertion. The third patient had only the screws removed, again at 4 months post-operation. In the remaining patient, the screws were left *in situ* as they were asymptomatic. There were 2 (3%) cases of AVN seen on radiographs (defined as collapse not present on the immediate post operative radiographs). AVN was first noted at the 2-year check in

a 48-year-old lady with a 2-part humeral fracture who had the plate removed for pain. The second case was in a 68-year-old lady with rheumatoid arthritis with a 2-part humeral neck fracture noted to have AVN at 6 months. There have been 4 (6%) superficial wound infections, all of which resolved with oral antibiotics. One further patient was admitted for 8 days, 6 days after initial discharge, for a wound infection which needed to be washed out. This patient was noted at one year follow-up to have asymptomatic backing out of the proximal screws which were left *in situ* (as mentioned earlier). A further patient developed compartment syndrome due to an intra-operative vascular injury, which was treated successfully with fasciotomies and vascular repair. This information is illustrated in figure 11. One patient aged 66 had a hemi-arthroplasty for

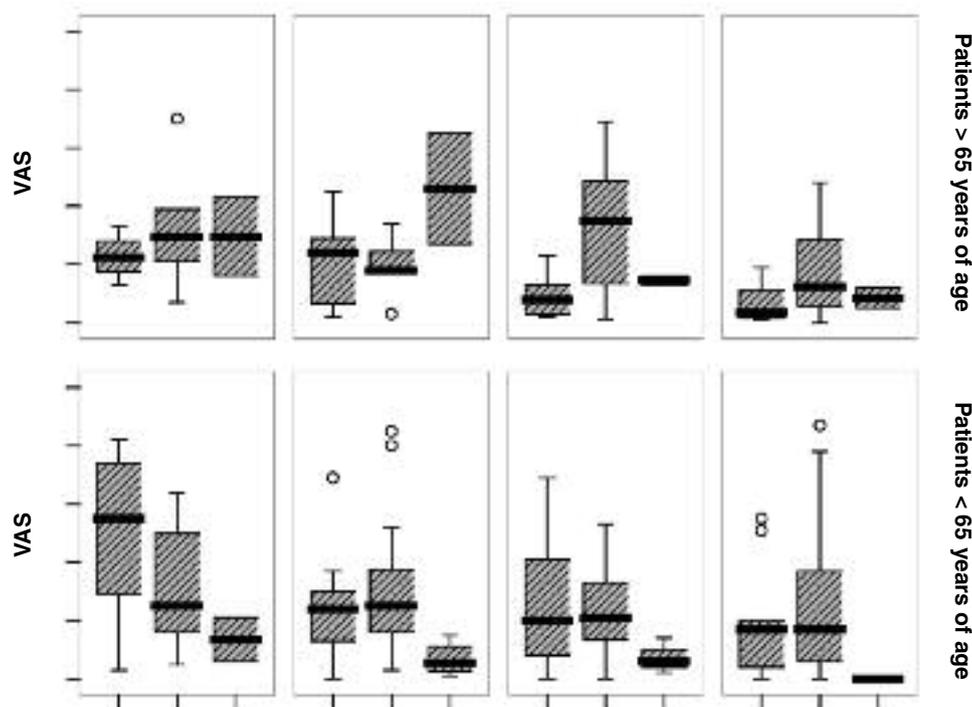


Fig. 9. — Box and Whisker plots for the VAS of the injured shoulder for each fracture group and for the over and under 65's

loss of reduction of a 4-part fracture 4 months post surgery, however she was followed up to the 2 year mark and her results included in analysis on the intent to treat basis.

DISCUSSION

The management of displaced fractures of the proximal humerus is a difficult area as is shown by the number of different techniques that have been proffered to treat these injuries. It has been suggested that surgical treatment offers no real benefit over conservative therapy (11), though these comments were made prior to specific techniques being available. This controversy may be lessened by the recent development of implants specifically designed for open reduction and internal fixation of proximal humeral fractures.

Specifically designed implants allow for the restoration of normal anatomy with stable fixation – the principle of treatment stated by Hoffmeyer (13). The PTP was an implant designed solely for treat-

ing proximal humeral fractures. It was unique in that it provided a means of securely re-attaching the tuberosities in their anatomical position. This has three immediate benefits. The first is to restore the soft tissue envelope which provides inherent stability to the reconstruction. The second is to reduce shortening of the musculotendinous units of the rotator cuff which in turn increases range of movement and strength. The third is the reduction of pain caused by secondary subacromial impingement. It also provided both angular and rotational stability via its two head screws. With these two unique design characteristics it was possible to reconstruct the anatomy of this complex joint that involves two major anatomical relationships (glenohumeral and glenosubacromial). This in turn reduces pain and aides restoration of function. Mean VAS scores of 20 at one year and CMS scores only 16% higher for the uninjured shoulder would appear to back this up.

It would be a fair observation of our results that operating on these difficult fractures is not without

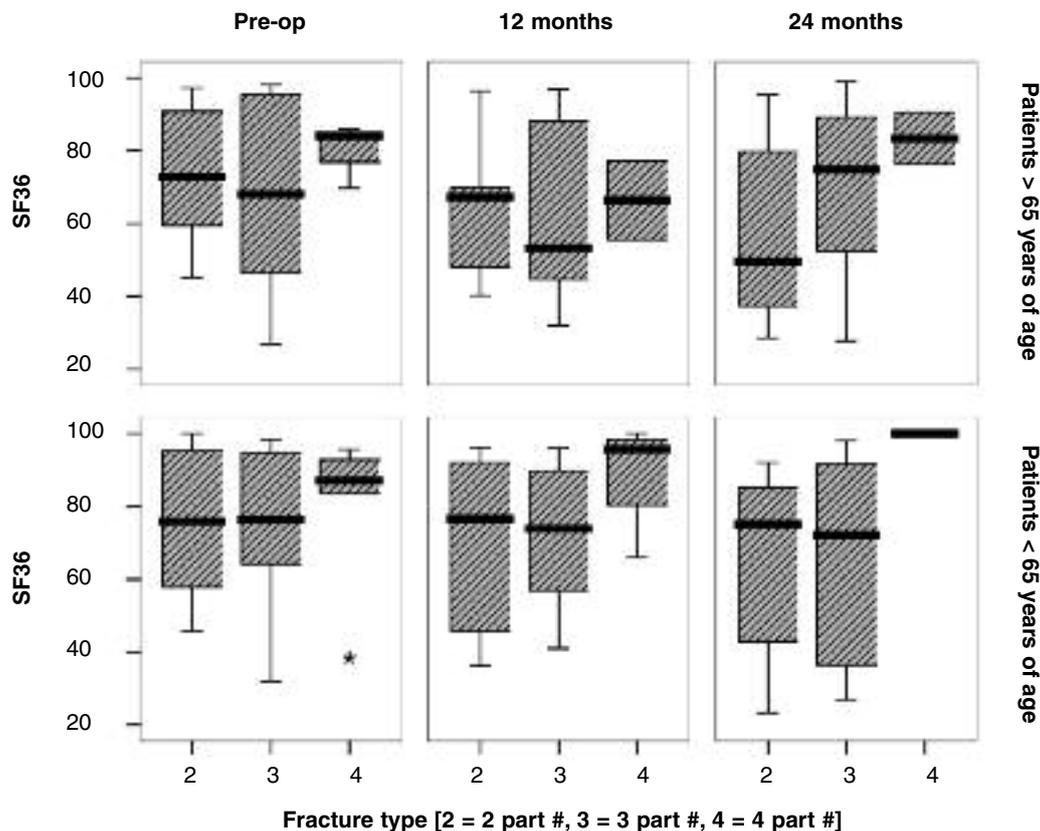


Fig. 10. — Box and Whisker plots for the SF-36 scores for each fracture type and for the over and under 65's

its risks. The vascular injury seen in one patient is indeed unfortunate, however this young man who was the victim of high energy polytrauma, including severe injuries to other limbs, has gone on to develop a pain free shoulder with a CMS of 100.

The fact that 6 of our patients were deceased by 12 months, albeit due to unrelated causes, is indicative of the more elderly population that we have seen in our patient group.

The most common complications reported in the literature after surgical treatment of fractures of the proximal humerus are stiffness, persistent pain, postoperative infection, failure of fixation, osteonecrosis and late rupture of the rotator cuff (6,19). Persistent pain may have several causes, such as: non-union, musculotendinous damage, migration of the implant, neurovascular damage, instability, capsulitis and low-grade infection (13).

The two most common problems that we observed were infection and cutting out of the head screws. The fact that all of our infections were superficial, with all but one, responding to oral antibiotics, and the absence of any deep infections leaves us unconcerned about this observation. The four patients that experienced the superior head screw cutting out all had united fractures at the time of implant removal, which is important as it shows that the implant had actually achieved its goal. Two of the patients have not required implant removal and would have been unaware of this problem was it not for our extended radiological follow-up.

Open reduction and internal fixation (ORIF) of severely comminuted and displaced fractures or fracture-dislocations have been believed to have an increased risk of avascular necrosis (11). Specific implants do not however, remove the need for

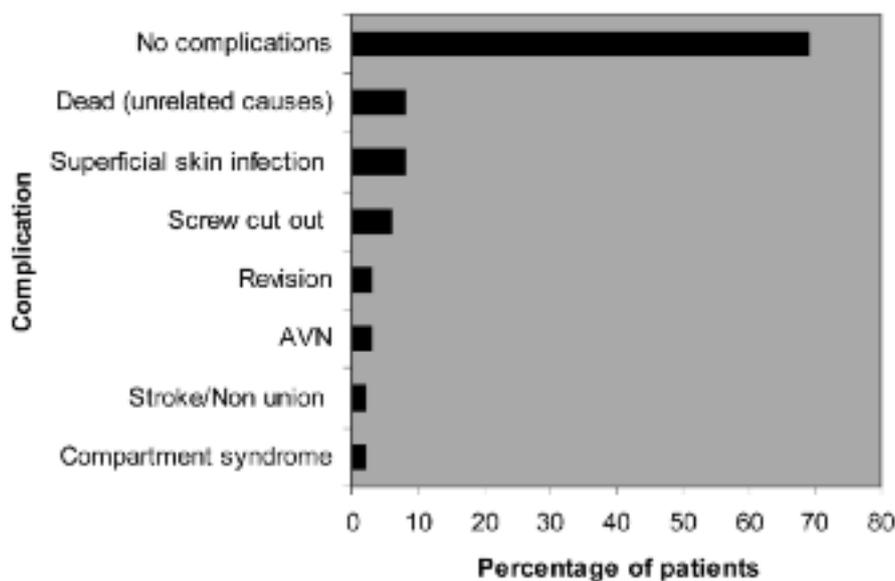


Fig. 11. — Complications encountered following ORIF with a PTP

meticulous soft tissue handling with attention to the maintenance of the vascular supply to the humeral head. This is predominantly via the ascending branch of the anterior humeral circumflex artery and its intraosseous anastomoses which must be preserved during surgery. Meticulous surgical technique will undoubtedly help to reduce the rate of avascular necrosis (AVN) (23,25). Our AVN rate at 12 months following surgery was 2% (1 patient) which is much lower than has previously been reported following plate fixation (25). However AVN and collapse of the humeral head may progress for a considerably longer period of time (2-3 years) (3) and the AVN rate at the 2 year follow-up was 3% (2 patients) which we feel to be a very acceptable level. With the use of an implant such as the PTP, stiffness is minimised due to adequate rehabilitation without the need for post-injury immobilisation. VAS scores at two years had a range of 0 to 78, with the mean being 22, suggesting that very few patients had persistent, severe pain. We found that the mean two year CMS score for the non-injured shoulder was only 16% higher than that for the injured shoulder, suggesting that patients had almost full recovery of function one year post injury (9% difference at 2 years). We did

find that the elderly patients with 4-part fractures experienced higher levels of pain for longer periods than their younger counterparts; however these levels became similar to the under 65's by 2 years. It is worth noting that traditionally most of these elderly patients with 4-part fractures would have been treated with a hemiarthroplasty whereas we have shown that these patients can be effectively managed with internal fixation, thus retaining their own humeral head, but that they will require extended physio input as their higher levels of pain seemed to be related to persistent stiffness. We have not seen any cases of instability in our cohort.

Many patients who sustain a proximal humeral fracture are elderly and their bones are osteoporotic (8); the use of operative treatment for such fractures in the elderly has been questioned (11). Indeed, the authors of one study believed that the PTP was contraindicated in elderly patients (22). The number involved in this particular study was too small (7 patients in total, 4 over 65) to allow any meaningful conclusion to be ascertained. In addition, the authors of this paper did not allow sufficient time for function to return and pain to subside before reporting their findings. One observation that we have made is that the elderly seem to take longer

than their younger counterparts to regain their function, but that patience and prolonged physiotherapy up to 24 months post surgery can still yield benefits in the elderly. Indeed we have shown that the PTP was successful in treating the elderly population with displaced 2-, 3- and 4-part proximal humeral fractures. Elderly patients are less able to compensate with a loss in function, than are younger patients (20). The stability provided by ORIF with a PTP allowed for immediate full range of motion shoulder exercises to optimise recovery to normal function. Other studies have shown that internal fixation of proximal humeral fractures in the elderly should be considered since it provides better pain relief, range of motion and maintenance of anatomical congruity than conservative methods offer (11, 12,18), and we feel that our results would agree with their findings. Burton *et al* (5) also found that they could not recommend the PTP in the elderly, but they did concede that a prospective study across a number of centres should be undertaken, which we have done. The only other paper in the English literature pertaining to the PTP by Machani *et al* (16) concluded that their results were less than satisfactory across their whole cohort of patients which was similar in size to ours. They sighted unacceptable deep infection rates and bulkiness of the implant to be their main concerns and they discontinued the use of the implant in their unit before it became unavailable due to the suppliers going into receivership. The problems of deep infection were not reflected in our series, or the series reported by Burton *et al* (5), so we are unable to comment on this problem, however we would tend to agree with the issue of the implant being bulky and although not formally recorded by us, many of our patients have reported an uncomfortable feeling from the bulky implant but not enough to require removal in most cases.

The PTP was the first implant on the market that specifically addressed proximal humeral fractures, as far as we are aware, and was unique in this respect. Since its introduction the market has moved on considerably with the introduction of lower profile locking plates by most of the implant manufacturers. All four of the units involved in this study have now moved on to using one of these newer

implants for their fixation of proximal humeral fractures for a variety of reasons most notably being the lower profile of the implants and the extended fixation provide by the multiple locking screw placement options that they offer. Indeed the PTP is no longer available for use as mentioned previously.

CONCLUSIONS

We feel that the PTP has played an important role in furthering the successful surgical management of displaced proximal humeral fractures. Having an implant specifically designed for this purpose allowed us to demonstrate that in conjunction with meticulous soft tissue handling intra-operatively and aggressive long term rehabilitation post-op, excellent outcomes can be achieved with internal fixation and that the previously quoted levels of AVN are not a reality.

We have shown the PTP was a useful implant for the management of unstable and displaced two, three and four-part proximal humeral fractures that could be used successfully in the elderly population as well as the young at a time when few other sensible options existed. Most importantly we have shown that operative intervention is a viable option for the treatment of these fractures in both the young and the elderly. The authors of this paper are convinced that the results of internal fixation of proximal humeral fractures will continue to improve with improvements in technology.

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