Proximal humeral fractures: A systematic review of treatment modalities

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A systematic review was conducted of primary intervention of proximal humeral fracture, which is a common injury with significant morbidity. Keywords of proximal humeral fracture were entered into PubMed and Embase databases. Two evaluators reviewed abstracts from 1985 to 2004 for inclusion and exclusion criteria yielding 66 articles. These articles were evaluated independently for outcomes and quality of evidence using the Structured Effectiveness Quality Evaluation Scale and Sackett’s Levels of Evidence. Patient characteristics and outcomes were recorded. The 66 studies included 2155 patients grouped by fracture types according to the Neer classification system. Studies differed by intervention, methods, outcome measures and results. Quality scores averaged 15/48; only 2 articles included randomized groups. Current studies typically lack randomization, comparators, and independent evaluation, with a resultant inability to produce clinical conclusions. Further research comparing primary treatment methods in a properly designed and controlled fashion is required, ideally using randomized controlled trials. (J Shoulder Elbow Surg 2008;17:42-54.)

Proximal humeral fractures (PHFs) are common and account for 10% of all fractures, with an incidence rate of 6.6/1000 person years. This injury is the 3rd most common fracture in the elderly population following hip and distal radius fractures and increases exponentially with age. Kannus et al indicated an increase in incidence of 13% per year between 1970 and 1993. PHFs remain a significant and growing medical concern because of the associated morbidity and epidemiological trends indicating an aging population.

Kocher is credited with the first fracture classification system in 1896. In 1934, Codman presented an anatomic classification, which was modified by Neer in 1970 to include concepts of displacement and vascularity. The AO classification is comprehensive with numerous subtypes that is based on vascular supply of the humeral head. Unfortunately, existing classification systems do not dictate how to treat PHFs, and the ideal treatment of this fracture remains a challenge for the orthopaedic surgeon. Treatment approaches to PHFs encompass a broad spectrum, including nonoperative treatment, percutaneous fixation, open reduction internal fixation (ORIF) with a variety of devices, and humeral head replacement (HHR). Although multiple studies have attempted to illustrate the benefits and weaknesses of PHF treatment options, drawing helpful conclusions from this evidence to guide treatment remains difficult.

To assess the scientific evidence of current treatment methods, a systematic review is conducted in a structured manner, including a review of the methodology and outcomes of each study. The use of consistent inclusion criteria, standard evaluation forms, and multiple raters minimized the potential for reviewer bias.

METHODS AND MATERIALS

A literature search of bibliographic databases with limitations of English language and human subjects using key words “proximal humeral fracture” was conducted. The databases utilized were the PubMed database that produced 415 articles, of which 112 were not English, as well as the OVID Embase database. Two independent evaluators analyzed abstracts and titles to identify articles that dealt with the treatment of proximal humeral fractures and met the study inclusion criteria. All articles selected by the evaluators were obtained and were included for systematic review if the following criteria were met:

(i) Type of study: Sackett levels 1-4 (randomized control trials, prospective trials, retrospective trials, and case series);
The results for each treatment subset was conducted. This come measures were comparable, a weighted average of and self-report disability measures. When the reported outcomes of each study for confounding variables, such as age, was not possible, as the statistical effect of the variable characteristics lacked homogeneity, and adjustment of the different tools of outcome measurement. Second, the patient characteristics encompassing 2653 patients who entered the study. The result measures chosen ranged from any combination of range of motion (ROM) values, strength in various planes of motion, radiological analysis, or subsequent complications, as well as ASES (American Shoulder and Elbow Surgery), Constant-Murley, Hawkins, HSS (Hospital for Special Surgery), Neer, UCLA (University of California-Los Angeles), VAS (Visual Analog Scale) scoring systems, and self-report disability measures. When the reported outcome measures were comparable, a weighted average of the results for each treatment subset was conducted. This enabled a comparison of Neer scores, pain, ROM, and complications, as these outcome measures were most consistently used. The other outcome measures listed above were used less frequently; therefore, comparisons between publications using these measures were not possible. ROM values were considered indicative of a difference in treatment if a variation of 10° or more existed. Meta-analysis of the

### Table I Structured Effectiveness Quality Evaluation Scale

<table>
<thead>
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<th>Study Question:</th>
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<td>1. Was relevant background work cited to establish a foundation for the research question?</td>
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<td>2. Were the study objective, analysis, and conclusions related to the intervention?</td>
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<tr>
<td>3. Was treatment providers randomized to the extent possible?</td>
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<td>4. Was an appropriate follow-up period incorporated?</td>
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<td>5. Was an appropriate enrollment obtained?</td>
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<td>6. Was an independent evaluation score assigned?</td>
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<td>7. Were the size and significance of the effects reported?</td>
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<td>8. Were missing data accounted for and considered in interpreting results?</td>
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<th>Study Design:</th>
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<td>25. Total Quality Score:</td>
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<td>26. Level of Evidence (Sackett):</td>
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The systematic review included a total of 66 publications encompassing 2653 patients who entered...
the studies and 2155 patients who completed follow-up. The average age of the patients included was 62.8 years, with 70% of these fractures occurring due to a fall from a standing height. The type of fracture with the highest average age was the 2-part fracture group at 69.4 years old, with 83% occurring as a result of a fall from an upright position. The lowest average age was 62.2 years old for the 3- and 4-part fracture group, with only 57% occurring due to a fall from a standing height. The dominant hand was involved in 48% of the fractures, and 82% of the patients entered in the included studies completed the follow-up period. During the follow-up period, 11.6% of the patients died (Table II). Using the Neer proximal humeral fracture classification,8 the patients were divided into groups of 2-, 3-, or 4-part fractures and combined groups of 2- and 3- or 3- and 4-part fractures. Except for the 4-part fracture group with 89 patients, each group contained at least 100 patients with the 2-, 3-, or 4-part group containing 574 patients and 411 patients with 3- or 4-part fractures (see Appendix I). Patients were further grouped according to treatment categories including nonoperative treatment with a sling or bandage, operative treatments utilizing percutaneous treatment, ORIF, and HHR.

### TREATMENT MODALITY

Nonoperative intervention included sling immobilization for 1-2 weeks followed by physiotherapy,13,41,46,88 swathe immobilization for 30 days followed by physiotherapy,9 or was not clearly defined.86

The ORIF group was further categorized into the subgroups of percutaneous treatment, plating fixation, intramedullary fixation, and miscellaneous fixation. Percutaneous treatment groups did not always specify whether the percutaneous devices were subcutaneous or transcutaneous at the conclusion of surgery. The use of smooth percutaneous K wires alone,34 in combination with screws7 or cannulated screws,9,85 has also been described. More complex percutaneous techniques included the use of external fixation frames: [Ilizarov® (Smith and Nephew, Memphis TN); Hoffman® (Stryker Howmedica, Mahwah NJ)] and K wires or pins to fix the fragments. Another combination technique involved 3 subcutaneous K wires with transosseous sutures.16 Hybrid treatment, including percutaneous treatment of bone fragments and the use of sutures to repair rotator cuff defects, has also been described.59 In general, transcutaneous and subcutaneous pins were removed 3-6 weeks after insertion. Percutaneous treatment was typically followed by a supportive bandaging technique, including a sling, swathe dressing, or other nonspecified methods of stabilization.

Multiple types of plate fixation have been used for ORIF. Reported techniques include T plating alone,44 with sutures,29 or a T or L plate used as a buttress,70 all fixed with cancellous and cortical screws. Cloverleaf plates have been modified by removing the superior and anterior arms, and screw fixation of the lesser tuberosity20 has also been reported. A number of blade plate techniques have been described including a standard blade plate, a bent limited contact dynamic compression plate with Schuhli washers,66 or an adolescent angular hip plate.31 Another option is double plating with a dynamic compression plate over the greater tuberosity and a second tubular plate over the ventral aspect.79

The different plating options available also allows for the intra-operative selection of a specific fixation method. For example, in the following reports, the intra-operative decision was made between impaction with tension-band fixation or a T plate,81 contoured semitubular or a T plate,51 T plate, cloverleaf, or small 90° bent tubular plates76 and semitubular plates bent to form a blade plate, or a T plate.51

A variety of intramedullary devices used alone or in conjunction with supplemental forms of fixation have been reported. Treatments include the use of 2 intramedullary K wires with a wire tension band passed through holes in the proximal end of K wires followed by a sling,15 3 to 4 retrograde intramedullary K wires followed by a sling,17 or 2 Rush pins® with fixation by tension band wire.67 Elastic nailing with 3-5 Zifko nailing®, with the addition of cerclage wiring and screws, were required.38 Two to 3 retrograde Prevot nails® supplemented, with the addition of 2 K wires if required (removed in 8 weeks) followed by a Velpeau sling,78 has also been described. Locked intramedullary nailing with devices— including the Polarus nail®, locked proximally and distally followed by a sling,93 and the Zickel supracondylar® rod with 2 screws used for proximal fixation followed by a sling—54 have also been reported.

### Table II Patient demographics

<table>
<thead>
<tr>
<th>Fracture Type-Patient Characteristics</th>
<th>Fall: standing height %</th>
<th>Average age (yrs)</th>
<th>Completion of study %</th>
<th>% Dominant hand fractured</th>
<th>% Died during follow up</th>
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<tbody>
<tr>
<td>Average Value</td>
<td>70</td>
<td>62.8</td>
<td>82</td>
<td>48.6</td>
<td>11.6</td>
</tr>
<tr>
<td>High Value</td>
<td>83~2-part</td>
<td>69.4~2-part</td>
<td>100~4-part</td>
<td>66.7~3, 3-4 &amp; 4-part</td>
<td>21~3-part</td>
</tr>
<tr>
<td>Low Value</td>
<td>57~3- &amp;4-part</td>
<td>62.2~3- &amp;4-part</td>
<td>62.3~3-part</td>
<td>44.4<del>2-3</del> &amp; 3-part</td>
<td>2.5<del>2-3</del> &amp; 3-part</td>
</tr>
</tbody>
</table>

1. Hoffman® (Stryker Howmedica, Mahwah NJ)
modular Bilboquet device® followed by a Mayo clinic bandage has been shown in one study. In most reports, the supplemental fixation was removed within 3 months of insertion.

The miscellaneous group was created for the treatment group of ORIF not involving an intramedullary device or plate for fixation. Tension band wiring techniques included the use of 2 wires followed by an abduction device, as required, or followed by a sling and the addition of K wires or a lag screw, as needed. Screws alone followed by a splint, or sutures alone to fix the bone fragments and a coexisting rotator cuff tear have been reported. The decision between AO screws, K wires, or K wires and cerclage wiring can be made intraoperatively. Also published is a technique using twisted wires contoured to the anterolateral aspect of the humerus with screws through the open holes of the twisted structure.

Arthroplasty was the final treatment option examined. A variety of prosthesis types have been used, including cemented Neer I, Neer II, or unspecified type or the majority cemented Neer type. The cemented modular Aequalis prosthesis was used exclusively in one study. No type of hemiarthroplasty was specified in one study. The remainder of the studies used a combination of Neer II, Fenlin, Biomedical, Global, Scan, Cofield, or Biomet types in which all were cemented or the majority cemented. In total, 14 Neer I, 94 Neer II, 51 unspecified Neer types, 71 modular Aequalis, 48 Biomedical, 23 Global, 22 modular Biomet, 15 Cofield, 3 Fenlin, Scan and 27 unspecified prosthetic devices were used.

**FRACTURE TYPES**

While the results of each fracture group is discussed in detail in the following paragraphs, the number of patients in each treatment subset of each fracture type are examined in Appendix II.

Each fracture group was discussed individually to discriminate the unique characteristics of their treatment and outcomes where the outcome measures are comparable (Figures 1-5). The Neer scores, pain values, subsequent complications, as well as the ROM values, were comparable. The pain measures occasionally needed to be approximated to fit into common categories. While these scores may not necessarily reflect the patient’s satisfaction with the outcome, they do represent measurable values that have gained acceptance in the orthopaedic community. Internal rotation was difficult to compare because of the large number of studies measuring the patient’s ability to reach to physical features such as vertebral level and the resultant inability to average the values.

**2-part fractures**

Two publications with level 3 evidence and 3 publications with level 4 evidence describing the treatment of 2-part fractures were systematically reviewed. Eighty-six percent of the 227 patients with 2-part fractures were treated with an intramedullary device. This included 3 to 4 bent intramedullary K wires followed by a sling or a humeral nail locked proximally and distally followed by a sling. Other treatments included suture to fix the fragments and...
a coexisting rotator cuff tear.\textsuperscript{22} Level 3 evidence was identified in 2 studies. The first study involved the retrospective comparison of 2 intramedullary Rush pins\textsuperscript{2} used to obtain tension band fixation, semitubular plate fixation, or T plate fixation.\textsuperscript{67} The second study examined nonoperative treatment versus flexible intramedullary nail combined with tension band wiring.\textsuperscript{14} Twenty-two patients who were treated with plate fixation had lower Neer scores than other treatments: a 54\% nonunion rate and a 18\% infection rate.\textsuperscript{67} This complication rate was substantially higher than the rates reported for other treatments. The amount of forward flexion of those treated only with sutures was $170^\circ$; greater than the $138^\circ$ reported with intramedullary devices.

2- or 3-part fractures

All publications of the 270 patients with 2- and 3-part fractures were defined as level 4 studies\textsuperscript{9,12,13,26,51,61,63,68} because they did not include the treatment of a comparison group. Treatment
interventions included sling immobilization for 1-2 weeks in 125 patients followed by physiotherapy. Percutaneous K wiring, including additional cannulated screws followed by the removal of some of the K wires at 4 weeks with the remainder being removed at 2 months, was also reported. ORIF techniques include sutures only, twisted wires contoured to surface and screwed to anterolateral aspect of humerus, tension band wiring techniques with the addition of a lag screw, or a variety of plates including the PlanTan Humerus Fixator plate, T plates, or semitubular plates bent to form blade plates. The intramedullary technique included in this group is the locked Polarus nail. No clear differences existed in outcome measures between these low quality studies; however, 1 article with a sample size of 7 demonstrated that all 4 patients over 70 years old failed plating treatment while those less than 65 years old had good outcomes.

3-part fractures

The number of reported patients with a 3-part fracture was relatively small (n=101), and all literature was of low quality (level 4) evidence. Treatments of 3-part fractures include using a sling to immobilize for 1-2 weeks followed by physiotherapy or an unspecified nonoperative treatment. Fixation methods include 3 K wires with transosseous sutures and buttress plate fixation using a T or L plate. HHR, using either Neer II, Biomodular®, or Global® prosthesis, with the majority being cemented, has also been reported. The 9 patients treated with buttress plating technique had the highest Neer and pain scores.

Figure 5 Range of Motion: Internal and External Rotation – refer to Appendix V for numerical values. Where: Nonop is non-operative ORIF: Intra, ORIF: Intramedullary; ORIF: Misc, ORIF: Miscellaneous; ORIF: Plate, ORIF: Plate; Hemiarthro, Hemiarthroplasty.

Figure 6 Summation of Quality of Evidence.
but no conclusions could be made on available data. Those treated with HHR had substantially lower values of forward flexion and abduction.

3- or 4-part fractures

Fourteen of the 15 papers that reported on outcomes following treatment of 3- or 4-part fractures were considered level 4 evidence, while the remaining paper was level 3 evidence. Three- and 4-part fractures have been treated by percutaneous methods with K wires and additional cannulated screws, with the subcutaneous K wires being removed after 4 weeks. A second study reported on the use of sutures to repair the rotator cuff, bone fragments, and additional threaded Steinmann pins when bone fragments were small or Hoffmann external fixation and Hoffmann pins when bone fragments were large (6 of the 16 cases).

Intramedullary techniques included 3-5 Zifko nailing® elastic wires, with the addition of cerclage wiring and screws where appropriate followed by a Gilchrist® dressing, a Polaris nail®, locked proximally and distally followed by a sling, or a Bilboquet device. Blade plate fixation with an adolescent angular hip plate or a cloverleaf plate, modified by removing the superior and anterior arms, has been used.

One-hundred and seventy-seven patients with 3- or 4-part fractures were treated with an HHR. These included a cemented Fenlin, Biomet, or Neer II, Neer II or Global, Neer II or Cofield, or an unspecified Neer type. Cement for implant fixation was used in the majority of cases or was not specified. In the level 3 study, the decision to use cerclage wire or T plates was made intraoperatively; a T plate was used when impaction of the humeral head onto the shaft did not result in a stable reduction. Patients with complex comminution, osteoporosis, or prolonged time to surgery were treated with a humeral head replacement. There was no difference in outcomes in the comparison of T plates or cerclage wiring. The ORIF miscellaneous group included a level 3 study comparing 21 patients treated with T plates and 39 patients treated with cerclage wiring, as well as a patient group treated with sutures and external fixation or threaded Steinmann pins. The ORIF miscellaneous group had greater Neer outcome scores and lower pain outcome measures than other treatment groups; however, these patients had a rate of AVN of almost 37%. Patients treated with an HHR had substantially lower forward flexion and abduction values than other treatment modalities.

4-part fractures

Eight level 4 publications describing the treatment of 4-part fractures were identified. Thirty-eight 4-part fractures were treated by a sling to immobilize the arm for 1-2 weeks, followed by physiotherapy or by an unspecified nonoperative treatment; but 17% developed osteoarthritis. Sutures alone have been demonstrated as have 2 intramedullary K wires, with a wire tension band through holes at proximal end of K wires. The decision between screws, K wires, or K wires and cerclage wiring can also be made intraoperatively. The ORIF miscellaneous group had the greatest degree of forward flexion, but 5 of the 19 fractures were found to have avascular necrosis. HHR was performed with a variety of prostheses including the Neer II, Biomodular, Cofield, and Global. The majority of the prostheses were inserted with cement. In one study, cementation of the Neer I implant was not specified. HHR had lower average values of both abduction and internal rotation.

Level 2 evidence

The literature search identified 2 small randomized controlled trials that were considered level 2 evidence. In the first publication, 30 patients were randomized to receive either closed reduction and a sling (mean age, 72 years) or percutaneous external fixation using a half-frame (mean age, 69 years). The proportion of 2-, 3-, and 4-part fractures was evenly divided between the 2 treatment groups. Quality of reduction was good in only 2 of the 16 treated with closed reduction and 11 of the 15 treated operatively. Neer scores were excellent or satisfactory in 4 of 10 treated with closed reduction and in 8 of 11 treated with external fixation. The authors concluded that the operative group had superior outcomes to the nonoperative group, based on the statistically significant difference in Neer scores and quality of reduction. There was 1 case of deep infection of the 12 treated with surgery. The authors suggest that deep infection and poor fixation in osteopenic bone remain a challenge to this treatment modality. The second publication randomized 37 patients with a 3-part fracture and 3 patients with a 4-part fracture (mean age, 74 years) to receive either nonoperative treatment or tension-band osteosynthesis. Based on a subjective questionnaire, Constant score, and complication rate, the authors concluded that the outcomes were similar between the groups but the rate of complications was higher in those patients treated surgically.

Quality of the evidence

The quality of the evidence currently present in literature was evaluated according to the SEQES to identify overall quality and source of design flaws across randomized and nonrandomized studies. Over 95% of the 66 studies established relevant background work for the research question; used
DISCUSSION

This study indicates that there is a wide variation in recommended treatments for fractures of the proximal humerus. The quality of the evidence is low and does not support any specific treatment choice. The treatment of a patient with a proximal humeral fracture represents a challenge to the orthopaedic surgeon for a number of reasons. Accurate assessment of fracture type can be difficult, as imaging assessment is imprecise. Accurate assessment of fracture type can be difficult, as imaging assessment is imprecise. Accurate assessment of fracture type can be difficult, as imaging assessment is imprecise. Accurate assessment of fracture type can be difficult, as imaging assessment is imprecise.

Obtaining and maintaining fracture reduction is especially difficult in the elderly patient with osteopenic bone. Publications included in this systematic review have methodological shortcomings in the areas of statistical analysis, comparison groups, randomization, and independent evaluation. Only 2 randomized trials were identified, and both compared nonoperative treatment to operative techniques that are considered mechanically inferior by today’s standards. Outcome measures used were numerous and included general health surveys, disease and joint specific surveys, and clinical measures including ROM and strength. The reliability of measures and the lack of uniform outcome measures further complicate attempts to conduct a statistical analysis of the literature.

To facilitate an evidence-based decision-making process, literature meta-analyses and systematic reviews are increasingly being utilized for an overview of our current understanding of optimal treatment methods. In this review, outcome measurement variability prevents meaningful statistical analyses and a meta-analysis was not possible. This systematic review does provide a better understanding of the patient characteristics and the diversity treatment options. To present data of greatest clinical significance, it was decided to discuss treatment outcomes as dependent on the patient’s presenting fracture type. The limitation of this approach is the lack of a reliable method for fracture classification.

The patient demographics presented in this systematic review are similar to other epidemiological studies. For example, the observation that 70% of fractures occur after a fall from standing height is comparable to the 75% in Kelsey et al and 74% in Palvanen et al. In some cases, patient characteristics are skewed by the low number of subjects within treatment groups or fracture type subgroups. Successful extraction of conclusions and treatment recommendations is hampered by the lack of uniform outcome measurement, differing methodology, and heterogeneous patient characteristics. Despite the above shortcomings, some valuable observations can be made with the data available. The literature demonstrates that the majority of 2-part fractures have been treated with an intramedullary device. A higher complication rate and inferior outcomes were observed in patients treated by a plating technique, although the sample size of 22 patients was small. Fractures treated with sutures alone had greater forward elevation than those treated with intramedullary devices. Robinson et al suggests that intramedullary devices are preferable to plate fixation in osteoporotic fractures of the elderly.

The articles describing outcomes following treatment of either 2- or 3-part fractures may be skewed, as the nonoperative group included valgus impacted fractures which are associated with a better outcome. Hardware failure in osteopenic bone is commonly discussed and has resulted in the various treatments including a twisted wire method, sutures, or tension band and lag screw techniques. Surprisingly, only one study described screw penetration of the humeral head when fixing a plate with locking screws. Firm conclusions about optimum treatment methods for either 2- or 3-part fractures cannot be made based on the evidence presented.

For patients with 3-part fractures, plating techniques resulted in the best outcomes, as measured by the Neer and pain scoring systems. However, only 9 patients with an average age of 47 years were treated with plate fixation. In contrast, the average age of patients treated either nonoperatively or with humeral head replacement was 71 years. No treatment group was clearly superior in terms of ROM measures. Three of the 5 articles in this subgroup were from the same author, including one level 2 publication. This author reported poor results following humeral head replacement. In comparing internal fixation to nonoperative treatment, better reductions were obtained in those patients treated with internal fixation. However, these patients had higher complication rates despite equivalent outcome measures to the nonoperative group; therefore, consideration of a nonoperative treatment is recommended by this author.
The majority of 3- or 4-part fractures have been treated with an HHR, and the remainder were treated in even proportions using percutaneous pinning, intramedullary fixation, sutures, wiring, or plating. Neer and pain outcome measures are most favorable in the ORIF miscellaneous group, using suture and an external fixation method, but, 37% of the patients had avascular necrosis. In 16 patients treated with internal sutures and external fixation, substantially better ROM measures were obtained. In these studies, AVN was not clinically significant from the patient’s perspective and there was no difference in outcome between cerclage and T plate treatments. The ORIF miscellaneous data group of percutaneous K wires, sutures, Steinmann pins, or Hoffman external fixation contained only 17% of the 411 patients with this type of fracture, and again represented patients averaging 52 years of age compared to 66.7 for the HHR group. The young age, small number of patients, and high AVN rates challenges the applicability of this treatment. Finally, although the outcomes of the comparison of cerclage wiring and T plating did not differ substantially, the patient groups were not equivalent because T plates were used to buttress fractures that were not stable post-reduction.

The outcomes reported following treatment of 4-part fractures again do not allow any conclusions to be drawn. Forty-seven percent of all patients treated with ORIF miscellaneous techniques were valgus impacted fractures which, as discussed previously, have a better prognosis; however, this group had a high rate of AVN at 24%. Those treated nonoperatively did have a 17% incidence of OA at the end of the 10-year follow-up.

Forward flexion, abduction, and internal rotation were all diminished to a greater degree in fractures treated with HHR when compared to alternative surgical treatment methods for 3- and 4-part fractures. Forward flexion motion is similar when 4-part fractures are treated with HHR or nonoperatively. External rotation following HHR was comparable to other treatment modalities.

The literature review identified two small randomized control trials. The first trial concluded that percutaneous reduction and external fixation had a superior outcome based on a statistically significant difference in Neer scores and the radiographic quality of reduction. However, their patient group had a single pin tract infection, and they stated that pin fixation in osteopenic bone and pin tract infections remain as challenges with this treatment modality. In a second article based on a subjective questionnaire, Constant score, and complication rate, the authors concluded that the outcomes were similar between nonoperative treatment and tension band fixation; however, complication rates were higher in patients treated surgically.

Two other systematic reviews have been published on the topic of PHF in the Cochrane database and another by Misra et al. The Cochrane database reviews randomized studies analyzing the treatment of proximal humeral fractures to draw conclusions from the highest quality evidence. Based on 12 randomized trials, this study came to a similar conclusion that the quality of evidence does not support valid decision making among surgical procedures, or even between operative and nonoperative treatments. Some of the studies accessed by the Cochrane review were not accessible in our review and would be unavailable to most clinicians. Only 7 of the 12 articles included were found on MEDLINE, and two of these were not in English. Misra et al conducted a systematic review of 24 studies describing the management and outcomes for 3- and 4-part fractures. Results were again inconclusive with a lack of definitive benefit to distinguish between humeral head arthroplasty and ORIF.

To add a further dimension to the analysis currently available, this study used different inclusion and exclusion criteria than previous work. Our study also adds to previous work by focusing on the variation in treatment approaches. All categories of proximal humeral fractures were reviewed to include the majority of evidence, which is of lower quality evidence, in an attempt to gain a further understanding by increasing the number of studies and patients. By doing so, it was possible to access and review a total of 66 articles encompassing 2155 patients in the current (1985-2004) literature. This may improve the applicability of this study for clinicians and yield a new perspective on the current literature.

The current literature indicates a trend to using intra-medullary devices for 2-part fractures and reserving HHR for complex fractures. However, the HHR typically produces an inferior ROM to other treatments. In general, plating techniques have great versatility of use, but are also high rates of complications. The inability to draw conclusions from the current literature, as well as the paucity of quality literature, demonstrates a need for higher quality evidence to enable the clinician to determine the optimal treatment interventions for each fracture.

Methodological flaws were consistently recognized in the areas of randomization, including a lack of comparators, absence of independent evaluation, and inadequate statistical significance or power. It is encouraging that the quality of evidence has improved over time, suggesting an increasing awareness of the importance of quality research design. Future clinical research should be conducted with greater methodological rigor and with standardized outcome reporting. Ideally, the use of randomized control trials would enable the direct comparison of the most commonly utilized treatment modalities while eliminating other variables.
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humerus fracture in old patients. A retrospective evaluation of 18
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arthroplasty for three- and four-part fractures of the proximal hu-

Appendix I
Number of patients per fracture group

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<th>Fracture type</th>
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<td>2 or 3 part</td>
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<tr>
<td>2, 3, or 4 part</td>
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<tr>
<td>3 part</td>
<td>101</td>
</tr>
<tr>
<td>3 or 4 part</td>
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Appendix II
Treatment modalities: Number of patients selected for each fracture type

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<th>Patients-numbers</th>
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<th>2- &amp; 3-part</th>
<th>3-part</th>
<th>3- &amp; 4-part</th>
<th>4-part</th>
<th>Total</th>
<th>Articles</th>
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Appendix III
Neer and Pain scores

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<th>Pain</th>
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<td>3- &amp; 4-part</td>
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Ex, Excellent; Sat, Satisfactory; Unsat, Unsatisfactory; Mod, Moderate; Sev, Severe; Non-op, Nonoperative; ORIF: Intra, ORIF Intramedullary; ORIF: Misc, ORIF Miscellaneous; ORIF: Plate, ORIF Plate; Hemiarthroplasty.
**Appendix IV Complications**

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Non-op, Nonoperative; ORIF: Intra, ORIF Intramedullary; ORIF: Misc, ORIF Miscellaneous; ORIF: Plate, ORIF Plate; Hemiarth, Hemiarthroplasty.

**Appendix V Outcome measures: Range of motion**

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Non-op, Nonoperative; ORIF: Intra, ORIF Intramedullary; ORIF: Misc, ORIF Miscellaneous; ORIF: Plate, ORIF Plate; Hemiarth, Hemiarthroplasty.