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Evidence based update: Open versus closed reduction

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ABSTRACT

Outcomes after operative treatment of displaced femoral neck fractures in young adults are fraught with high complications rates including non-union and avascular necrosis. Among the therapeutic controversies that persist is the role of open reduction, which would allow surgeons a direct means to improve the quality of reduction, a predictor of successful treatment. We performed a systematic review of the literature to compare the outcomes (nonunion, avascular necrosis, and deep infection) after open reduction with internal fixation (ORIF) to closed reduction with internal fixation (CRIF) of acute (surgery performed less than 6 weeks from injury) femoral neck fractures in young adults (average age of 50 or younger) followed for at least one year. Despite the large literature investigating outcomes after operative treatment of femoral neck fracture, relatively few studies aimed to determine the relative risk of complications associated with method of reduction. Therefore, both observational and randomised studies as well as case series with clear descriptions of surgical approach and outcomes were included. We identified 21 studies that matched our inclusion criteria. The incidence of nonunion was 11.6% in closed reduction and 14.9% in the open reduction group ($P = 0.25$). The incidence of avascular necrosis for CRIF and ORIF were 17.2% and 17.7% respectively ($P = 0.91$). The incidence of deep wound infection was 0.49% in the closed reduction group and 3.9% in the open reduction group ($P = 0.0019$). Meta-analysis of risk ratios estimated from six of the studies with comparative data revealed no significant difference in the incidence of nonunion, avascular necrosis or total complications between the two reduction techniques. In summary, systematic review of the literature reveals a lack of evidence in support of ORIF versus CRIF as a means of treating displaced femoral neck fractures in young patients with respect to union and avascular necrosis; however, the incidence of surgical site infections may be lower with CRIF. Firm conclusions cannot be drawn given the lack of high quality prospective studies and patient reported outcomes. In the future, randomised controlled trials will be required to test the effect of reduction method.

Introduction

Femoral neck fractures are a major cause of morbidity and substantial health-care cost in the United States. There are more than 250,000 cases of hip fractures in the United States annually with an overwhelming majority of these fractures occurring in the elderly [1,2]. Approximately 3% of intracapsular hip fractures occur in patients under the age of fifty [3–5] and are usually associated with more severe and higher energy injuries compared to older patients [6]. Femoral neck fractures in the young adult population are associated with a high complication rate with the two most common being non-union and avascular necrosis (AVN) [7–12]. Disruption of the femoral head's blood supply associated with higher energy injuries has been proposed as a possible reason for higher risk of nonunion and avascular necrosis in this age group [10].

Although there is strong evidence supporting the use of arthroplasty in treatment of displaced femoral neck fractures (Garden type III or IV) in the elderly [13–15], fracture repair and joint preservation are priorities in operative treatment in the physiologically young patient. Still, what constitutes a young patient and treatment variables including optimal timing of surgery, approach to reduction, capsulotomy and choice and configuration of implants remain controversial [16]. Among these modifiable treatment variables, quality of fracture reduction has been on of the most consistently shown predictors of treatment

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success [12,18,19]. While performing a direct reduction would ostensibly improve surgeon control over this determinant of outcome, it is unresolved as to whether open reduction (ORIF) of these fractures leads to better clinical outcomes than closed reduction (CRIF) [8,17]. We conducted a systematic review on the topic to help elucidate whether one method of reduction is superior with respect to clinical outcomes and rates of complications, namely avascular necrosis and nonunion.

Materials and methods

We conducted a systematic literature search of MEDLINE and electronic databases of *The Journal of Bone and Joint Surgery* (American Volume) and *The Bone and Joint Journal (formerly the Journal of Bone and Joint Surgery*-British Volume) for articles that reported on outcomes of open versus closed reduction of acute femoral neck fractures in young adults. An academic librarian assisted the team to assure a comprehensive and reproducible search of these databases. Free text, medical subject headings (MeSH) and keywords were used for our initial literature search. Our search was restricted to human subjects and articles available in English. Studies published in any year were considered for inclusion. References of the identified articles were also reviewed for additional relevant studies.

Inclusion and exclusion criteria

Studies that reported the incidence of complications and reoperations after ORIF or CRIF of displaced femoral neck fractures in skeletally mature patients with an average age of 50 or less were included in our analysis. A minimum of 12 months of follow-up and surgical delay of no longer than 6 weeks from the time of injury were required for inclusion. While comparative studies of the two approaches to reduction were sought, case series that clearly described means of reduction in the target population with adequately recorded follow-up were included. We excluded studies of pathological fractures, non-operative treatment, or arthroplasty for the femoral neck fractures. Use of bone grafts or muscle pedicle grafts during the initial surgical treatment of the fractures was not an exclusion criterion. Studies that only reported on operative outcomes of nondisplaced or minimally displaced femoral neck fractures were excluded.

Study selection and data extraction

Title and abstract review of articles resulting from the initial literature search was performed in parallel by two authors and articles selected by either were pulled for full text review. The two reviewers agreed on the final inclusions by consensus. Extracted data included number of patients that underwent closed reduction internal fixation (CRIF) or open reduction internal fixation (ORIF), number of complications, including avascular necrosis, delayed union and nonunions, and deep wound infections at minimum of one year follow-up after the initial treatment of displaced femoral neck fractures. Additionally, when available, numbers of non-displaced versus displaced femoral neck fractures were identified as defined by the Garden criteria and only fractures identified as displaced (Garden III and IV) were analyzed [18].

Synthesis

Descriptive statistics summarizing characteristics of the study sample from each of the included studies was performed using means and proportions. Incident cases from each treatment group of nonunions, avascular necrosis, deep wound infections, and combined complications were pooled across all included studies and divided by the treatment specific population from each of those studies in order to estimate a summary incidence estimates. These summary measures of risk were compared between treatment groups using the Fisher's exact test.

Comparative studies were meta-analyzed in order to estimate summary risk ratios for nonunion, avascular necrosis and total complications. Relative risks of these complications for closed reduced versus open reduced fractures and the associated 95% confidence intervals (CI) were calculated in STATA version 12 (College Station, TX). Heterogeneity was measured using the chi-squared test, and decision to use fixed-effect versus random-effect models was made based on evidence for heterogeneity ($P < 0.2$).

Results

274 relevant studies were initially identified, which were subsequently reduced to 151 after removal of duplicates and studies with non-human study models, non-English articles, and studies that used methods other than internal fixation as their primary method of treatment. The title and abstract review by two different reviewers identified 50 articles that met inclusion criteria. Selection from this full-text review resulted in a final list of 21 articles for data extraction [5,6,9,10,17,19–34]. Disagreements were resolved by consensus. The selection and screening process is summarised in Fig. 1.

A summary of the characteristics of the included studies is shown in Table 1. Majority of the studies that met our inclusion criteria were case series with varying number of patients and duration of follow-up. Two studies included in our final review had an average age of more than 50, but the outcomes were stratified by age and were specifically available for patients younger than 50 [28,30]. For one study we had to combine the number of displaced and nondisplaced fractures given the lack of outcomes data on displaced fractures alone [5]. There was only one randomised controlled trial included in our analysis [17]. None of the studies had clinical follow-up of less than one year (Table 2).

The incidence of nonunion was 11.6% in the closed reduction group and 14.9% in the open reduction ($P = 0.25$). The rate of avascular necrosis for closed reduced and open reduced fractures were 17.2% and 17.7% respectively ($P = 0.91$). For deep wound infection, the incidence was 0.49% in the closed reduction group and 3.9% in the open reduction group ($P = 0.0019$). For overall complication rate, which includes the sum of all cases of nonunion, avascular necrosis and deep wound infection, the incidence was 29.2% for fractures treated with closed reduction and 36.5% in those that underwent open reduction ($P = 0.68$).

Meta-analysis was used to summarise the result of the six comparative studies included in this review (Figs. 2–4) [6,17,21,26,32,34]. For avascular necrosis there was no significant difference in the incidence of avascular necrosis between the open reduced and closed reduced fractures (RR: 0.75; 95% CI: 0.42–1.34). A fixed effect model was used in meta-analysis of avascular necrosis since there was low level of heterogeneity among studies (Chi-squared = 4.98; df = 5; $P = 0.42$). In contrast, in meta-analysis of rate of nonunion (Chi-squared = 18.5; df = 5; $P = 0.002$) and total complications (Chi-squared = 17.31; df = 5; $P = 0.004$) among these six studies, random-effect models were used given the evidence of statistical heterogeneity. Similar results were obtained for rate of nonunion among theses studies with no significant difference in incidence between the two methods of reduction (RR: 0.86; 95% CI: 0.49–1.49). Also, there was no association between the incidence of total combined complications and the method of reduction in our analysis (RR: 0.65; 95% CI: 0.33–1.03).