Original research

Meta-analysis of the outcomes of intramedullary nailing and plate fixation of humeral shaft fractures

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ABSTRACT

Objective: The purpose of this study is to compare the outcomes of intramedullary nailing and plate fixation in the treatment of humeral shaft fractures using meta-analysis.

Methods: PubMed, MEDLINE, EMBASE, the Cochrane Controlled Clinical Trials Register (CCTR) databases were searched for studies that investigated the efficacy of intramedullary nailing and plate fixation in the management of humeral shaft fractures. Delayed healing rate, nonunion, postoperative infection and radial nerve paralysis were key outcomes of interest. Data were searched within the time period of July 1990 through September 2012. The statistical software RevMan 5.0 was used to analyze the statistical significance of the results.

Results: Total 459 cases of patients in 10 literature, including 231 cases of plate group and 228 cases of the intramedullary nailing groups were collected. The results of meta-analysis showed that delayed healing rate of humeral shaft fractures was lower in plate fixation compared with intramedullary nailing (RR = 2.64, 95% CI (1.08, 6.49), P < 0.05). No statistically significant difference in nonunion, postoperative infections, radial nerve paralysis and other complications was identified between nailing and plate fixation groups (P > 0.05).

Conclusions: In general, the effect size of intramedullary nailing may be comparable to that of plate fixation in the treatment of humeral shaft fractures. Delayed healing rate, nonunion is the event of delayed healing rate.

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1. Introduction

Humeral shaft fractures are commonly encountered in surgical, accounting for 1.31%–3% of all fractures. Several fractures of the humeral shaft can be treated with conservative treatment, but internal fixation is widely performed when there is major soft-tissue injury or multiple trauma, persistent malalignment, nonunion or pathological fracture. The strengths and weaknesses of intramedullary nailing and plate fixation have been well discussed. Plate fixation favors high rates of union, but requires an extensive open operation, with stripping soft tissue from bone. It is likely to cause complications, including delayed or nonunion of bone healing and radial nerve injury. In other hand, recent studies have showed that intramedullary nailing easily injured shoulder function and lead to the loss of shoulder motion. Moreover, the closed intramedullary nailing can cause a poor rate of union but it can theoretically avoid the damage of soft tissue or periosteum, various unlocked nailing.

The exact efficacy of plate fixation and intramedullary nailing still remains debated. Over the past decade, there have been many randomized controlled studies on plate fixation and intramedullary nailing fixation of humeral shaft fractures. However, these studies were limited in sample size and quality of methodology. Thus, we...
conducted a meta-analysis to compare the efficacy of these two methods in treatment of patients with humeral shaft fractures, providing a reference for clinical decision making.

2. Materials and methods

2.1. Literature retrieval

To collect research literature involving the treatment of steel plate fixation and intramedullary in humeral shaft fracture, we conducted a systematic literature search from the PubMed, MEDLINE, EMBASE, the Cochrane Controlled Trials Register (CCTR) databases (up to September 2012) using the following search terms: humer* fractures AND nailing*; humer* fractures AND plate OR plating; intramedullary nailing* OR plate AND humer*; humer* fixation. The language of publication was Chinese or English.

2.2. Literature screening

Studies were eligible if (1) published literature at home and abroad; (2) the experimental design was randomized controlled trials (RCT) or controlled clinical trials (CCT); (3) the year of study carried out or publication was stated; (4) sample size was defined clearly; (5) the patients with humeral fractures had a significant indication for surgery; (6) method of treatment was intramedullary nailing or plate fixation; (7) literature results were comparisons of the incidence of nonunion, delayed healing, infection after surgery or radial nerve palsy; (8) data collection methods were scientific; and (9) data analysis method was correct.

Studies were excluded if (1) the source of cases and controls were not provided. Non-therapeutic clinical research, animal experiments, non-original literature and no clear grouping number; (2) diagnostic criteria were not clear; (3) trauma patients without humeral fractures; (4) treatment methods were not intramedullary nailing or plate fixation but others; (5) data collection methods were unscientific; (6) there was no control group; (7) data analysis methods were wrong or not provided; (8) introduction of methodology without treatment results; (9) review or repeating literature; and (10) retrospective analysis (RA).

2.3. Data extraction

In order to extract the information needed, all articles were reviewed and separately collated by two independent investigators who checked for any discordance and reached a consensus. The following information was evaluated and extracted from each study: first author, publication year, published journal, design proposal, characteristics, sample sizes and outcomes of the cases and controls and result of research. Any disagreements were resolved by consensus.

2.4. Statistical analysis

Relative risk (RR) and 95% confidence intervals (CI) were calculated by using the Mantel-Haenszel method. Meta-analysis was performed using RevMan 5.0 Software. A P value ≤ 0.05 was considered statistically significant. If the heterogeneity exists, random effects model would be used to estimate pooled RR data. Otherwise, the fixed effects model would be adopted.

3. Results

3.1. Studies included in the meta-analysis

The initial search yielded 89 unique citations, of which 10 studies on plate fixation and intramedullary nailing fixation of humeral shaft fractures met the inclusion criteria and were selected as appropriate for inclusion in this meta-analysis. The first author, publication year, published journal, number of patients, follow-up time and jaded score of included studies were listed in Table 1. The studies yielded a total of 459 patients, including 231 cases in plate fixation group and 228 cases in intramedullary nailing group. In the 10 included studies, the number of cases in each study ranged from 28 to 84 and the publication year ranged from 1995 to 2011.

![Fig. 1. Meta-analysis results for nonunion incidence rate of humeral shaft fracture between the two groups.](image)
3.2. Comparison of the two groups’ observation index

3.2.1. Comparison of nonunion incidence rate between plate fixation group and intramedullary nailing group

All 10 studies\(^8\)–\(^17\) reported the comparison of nonunion between two groups, including 228 patients in intramedullary nailing group and the 231 patients in plate fixation group. Test statistics showed evidence of no heterogeneity among these studies \((P = 0.85, I^2 = 0\% )\) and fixed-effects model was adopted. There was no statistical difference between intramedullary nailing group and plate fixation group in incidence rate of nonunion \((RR = 1.12, 95\% CI = 0.61–2.08; \text{Fig. 1})\).

3.2.2. Comparison of delayed union incidence between plate fixation group and intramedullary nailing group

Comparison of the occurrence of delayed union was available in only three studies.\(^10,13,17\) There were 85 patients in intramedullary nailing group and 89 patients in plate fixation group. Fixed-effects model was used to estimate pooled RRs because test statistics showed no evidence of heterogeneity among these studies \((P = 0.63, I^2 = 0\% )\). Result showed that the incidence of delayed union was higher in intramedullary nailing group than that in plate fixation group \((RR = 2.64, 95\% CI = 1.08–6.49; \text{Fig. 2})\).

3.2.3. Comparison of infection incidence rate between plate fixation group and intramedullary nailing group

The Forest plot for the RR between the intramedullary nailing group and plate fixation group in terms of postoperative infection is shown in \text{Fig. 3}.\(^9\)–\(^11,13–17\) Fixed-effects model was used to estimate pooled RRs because test statistics showed no evidence of heterogeneity among these studies \((P = 0.65, I^2 = 0\% )\). No significant difference of the incidence of postoperative infection was identified between these two groups \((RR = 0.43, 95\% CI = 0.18–1.06; \text{Fig. 3})\).

3.2.4. Comparison of the incidence rate of radial nerve palsy between plate fixation group and intramedullary nailing group

Nine studies investigated the difference of radial nerve palsy between these two groups.\(^9\)–\(^17\) Because of homogeneity in the literature \((P = 0.38, I^2 = 0\% )\), the fixed effects model was performed, which showed that the RR between these two groups were not significant \((RR = 0.55, 95\% CI = 0.26–1.17; \text{Fig. 4})\).

3.2.5. Publication bias

Publication bias occurs if studies with small effect size or those showing no significant difference between the two approaches of fixation are not reported. \text{Fig. 5} shows the funnel plot based on studies with data on total complications (as this was the outcome that most studies included in their meta-analysis), which is symmetrical, and indicates that our study is not subject to this bias.

4. Discussion

Meta-analysis is the main result of the comparison of intramedullary nailing and plate fixation in treatment of humeral shaft fractures. In the present study, we added the newest literature\(^13\) and reduced the publication bias. All included 10 studies were
derived from the United States, China, United Kingdom and other countries, respectively. They were slightly different in design proposal of study, and all of them were published in English. We did not retrieve the literature in other languages, and thus the language bias might have some impact in this article.

Most of our results were consistent with previous meta-analyses, except the result of comparison of delayed union incidence rate.\(^\text{18,19}\) In our study, we found that the delayed union incidence rate of humeral shaft fracture between plate fixation group and intramedullary nailing group has a significant difference \((P < 0.05)\).

As we all know, plate treatment of humeral shaft fracture surgery increases the exposed surface and the amount of blood loss, thus increases the risk of infection. To reduce the chance of infection, we prefer to use intramedullary nailing treatment in clinical. However, our meta-analysis revealed that the infection incidence rate had no statistically significant difference between the two fixation groups.

Moreover, the incidence rate of radial nerve palsy is usually 2%–17%, but clinically, only a small part of the patients need surgical treatment.\(^\text{20,21}\) Although the prognosis is good, the radial nerve palsy may usually reduce the satisfaction of patients. Our meta-analysis indicates that the incidence rate of postoperative radial nerve palsy and nonunion have no significant difference between these two approaches, which was in line with the results reported by Bhandari and Ouyang.\(^\text{18,19}\)

Several limitations of this meta-analysis should be acknowledged. Intramedullary nailing and plate fixation can cause impairment of shoulder mobility, iatrogenic crushed fracture, implant failure and other complications.\(^\text{22,23}\) Other complications should be considered to evaluate the effect size of these two approaches for the treatment of patients with humeral shaft fractures, which should be studied in the future research. Additionally, this meta-analysis did not report the different degree of the injury, different age group and genders, which may influence the final results.

In conclusions, there was no significant difference between plate fixation group and intramedullary nailing group in nonunion, infection, radial nerve palsy. The incidence of delayed union was slightly higher in intramedullary nailing compared to plate fixation. In clinical application, surgeons should select the appropriate treatment method according to the actual situation.

**Ethical approval**

None declared.

**Funding**

None declared.

**Author contribution**

Guo-dong Liu and Shan Ou: study conception and design; Qing-gang Zhang and Le-shun Zhou, Jun Fei and Guo-xin Nan: revise the article critically; Hong-wei Chen: acquire of data, analysis and interpretation of data; Guo-xin Nan: draft the manuscript.

**Conflict of interest**

None declared.

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