Open reduction and closed reduction internal fixation in treatment of femoral neck fractures: a meta-analysis

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Abstract

Background: A meta-analysis was performed to assess the association between healing rate, avascular necrosis (AVN) of femoral head and two reductions-open reduction internal fixation (ORIF) and closed reduction internal fixation (CRIF) for femoral neck fracture.

Methods: A literature-based search was conducted to identify all relevant studies published before September 10, 2013. The odd ratio (OR) and 95% confidence interval (CI) were used for estimating the effects of the two reduction methods. Data were independently extracted by two investigators who reached a consensus on all of the items. The heterogeneity between studies was examined by $\chi^2$-based Q statistic. Egger's regression analysis was used to evaluate publication bias. Statistical analysis was performed by Stata 10.0 software.

Results: We examined 14 publications. The results of the present meta-analysis showed that AVN of femoral head were significant associated with the two reductions (CRIF vs. ORIF, OR = 1.746, 95% CI 1.159-2.628, $p = 0.008$), while the healing rate were not (CRIF vs. ORIF, OR = 0.853, 95% CI 0.573-1.270, $p = 0.433$).

Conclusion: The present meta-analysis indicated the risk of AVN of femoral head was significant higher after CRIF fixation compared with ORIF, but no association between the healing rate and the two reductions for femoral neck fracture.

Keywords: Femoral neck fracture, Open reduction internal fixation, Closed reduction internal fixation

Background

Femoral neck fracture, known as hip fracture, occurs in the proximal end of the femur near the hip, and is often due to osteoporosis [1]. The incidence of femoral neck fracture is increasing at an exponential rate as a result of the longevity of the general population [2]. It is one of the most common consequences of injuries in the elderly population [3]. Despite advances in surgical techniques and medical care, the risk of nonunion and avascular necrosis (AVN) of femoral head after fixation have not changed appreciably in the last 50 years [4].

Emergency internal fixation is one of the main options for the treatment of displaced femoral neck fractures [5]. It contains open reduction internal fixation (ORIF) and closed reduction internal fixation (CRIF). Both of the two methods have their advantages and disadvantages [6]. Although ORIF has advantages of direct look and restoration of normal function, its application still limited by the potential negative effects of nerve damage, swelling, incomplete healing of the bone, increased pressure and blood clot [7]. CRIF has advantages of avoiding injury to the medial circumflex femoral artery [8]. However, intracapsular pressure formed by CRIF compromised femoral head circulation, and prolonged extension and internal rotation position on the fracture table reduced the blood supply to the femoral head, what's more, the repeated forceful manipulation increased the risk of AVN [6]. Thus, the optimal treatment of femoral

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The healing rate of ORIF and CRIF

A total of nine studies [11-19] met the inclusion and exclusion criteria in the meta-analysis of healing rate of ORIF and CRIF (Table 1), which contained 405 patients of ORIF and 442 patients of CRIF. Egger's regression analysis indicated no publication bias (p = 0.462). No significant heterogeneity was observed among studies (p = 0.462), so a fixed effect model was used and generated a combined OR of 0.853 (95% CI 0.573-1.270). Meta-analysis showed that no significant association between the healing rate and the two reductions (p = 0.433), and the forest plot was presents at Figure 2.

The AVN of ORIF and CRIF

A total of eleven studies [11,12,14,16-18,20-24] met the inclusion and exclusion criteria in the meta-analysis between AVN and the two reductions (Table 2), which contained 478 patients of ORIF and 505 patients of CRIF. Egger regression analysis indicated no publication bias (p = 0.462). No significant heterogeneity was observed among studies (p = 0.462), so a fixed effect model was used and generated a combined OR of 0.853 (95% CI 0.573-1.270). Meta-analysis showed that no significant association between AVN and the two reductions (p = 0.433), and the forest plot was presents at Figure 2.
bias (p = 0.257). No significant heterogeneity was observed among studies (p = 0.507), so a fixed effect model was used and generated a combined OR of 1.746 (95% CI 1.159-2.628). Meta-analysis showed that significant association between AVN and the two reductions (p = 0.008), and the forest plot was presented at Figure 3.

**Discussion**

Femoral neck plays an important role in weight bearing and movement. ORIF and CRIF are the two common techniques to cure femoral neck fractures. The results of the present meta-analysis showed that there was significant

| Study     | Year | ORIF Union | ORIF Nonunion | CRIF Union | CRIF Nonunion |
|-----------|------|------------|---------------|------------|---------------|
| Liu [11]  | 2003 | 21         | 21            | 33         | 23            |
| Wang [12] | 2005 | 19         | 1             | 41         | 1             |
| Song [13] | 2010 | 14         | 1             | 7          | 5             |
| Zhang [14]| 2011 | 47         | 3             | 48         | 2             |
| Ye [15]   | 2011 | 16         | 12            | 19         | 13            |
| Lin [16]  | 2012 | 18         | 1             | 12         | 3             |
| Zhou [17] | 2012 | 124        | 13            | 113        | 8             |
| Xia [18]  | 2013 | 37         | 3             | 33         | 3             |
| Zhang [19]| 2013 | 43         | 11            | 68         | 10            |

**Table 1 Characteristics of studies included in the meta-analysis of the nonunion rate between the two groups**

| Study     | Year | Normal AVN | Normal AVN |
|-----------|------|------------|------------|
| Liu [11]  | 2003 | 40         | 2          |
| Upadhyay [20] | 2004 | 36         | 8          |
| Wang [12] | 2005 | 18         | 2          |
| Gao [21] | 2008 | 25         | 3          |
| Zhang [14] | 2011 | 49         | 1          |
| Kan [22] | 2011 | 44         | 5          |
| Kan [23] | 2011 | 15         | 3          |
| Lin [16] | 2012 | 19         | 0          |
| Zhou [17] | 2012 | 126        | 11         |
| Xia [18] | 2013 | 37         | 3          |
| Mohammad [24] | 2013 | 26         | 5          |

**Table 2 Characteristics of studies included in the meta-analysis of AVN between the two groups**

**Figure 2 Forest plots of meta-analysis of nonunion rate.** Closed reduction internal fixation vs. open reduction internal fixation.
incidence of AVN of femoral head in CRIF was significant higher than ORIF (OR = 1.746, 95% CI 1.159-2.628, p = 0.008). This might be caused by the pressure of CRIF that compromised the blood supply to the femoral head [6].

Nonunion is caused by a combination of unfavorable biomechanical and vascular conditions, ignoring general contraindications, and inadequate internal fixation [29]. It also related to age, the quality of bone and the pattern of fracture [20]. It was reported that the risk of nonunion was higher in female than male [30]. The effect of smoking and alcohol drinking may also influence the rate of nonunion [31]. Our meta-analysis showed that there was no significant difference of the healing rate between CRIF and ORIF (OR = 0.853, 95% CI 0.573-1.270, p = 0.433).

The early treatment of femoral neck fracture is critical. CRIF is prior for patients with good blood perfusion of the femoral head while the ORIF should be selected for those with poor blood perfusion [12]. It was reported that gentle closed reduction should be tried first, with a maximum of one or two reduction attempts, which could prevent greater displacement with risk of greater damage to the blood supply [32]. Once the CRIF failed, then ORIF should be performed [33]. However, this may increase the risk of AVN as the result of the present study indicated, thus, ORIF is recommended.

There were several limitations in the present meta-analysis that should be noted. First, publication bias, an inherent limitation of all meta-analyses, may still exist because researchers are less likely to publish negative findings, although Egger’s regression analysis did not suggest publication bias in this study. Second, the confounding variables (age, sex, smoking, or alcohol intake) were not adjusted because most of studies didn’t provide respective OR value or sufficient data for calculating OR. Besides, different types of reduction devices may affect the results. Third, we did not perform subgroup analysis for different type of femoral neck fracture because the classifications varied from different studies including Garden [34], Pauwels [35] and Delbet [36] classification. Despite these limitations, the study is still of great importance for evaluating the effects of two reductions for femoral neck fracture treatment, especially considering the main complication - AVN.

**Conclusion**

In conclusion, our meta-analysis suggested that the risk of AVN of femoral head was significant higher after CRIF compared with ORIF, while there was no significant difference of the healing rate between the two reductions. ORIF offers advantage over CRIF in terms of AVN for treatment of the femoral neck fractures.

**Consent**

Written informed consent was obtained from the patient for the publication of this report and any accompanying images.
Competing interests
We certify that regarding this paper, no actual or potential conflicts of interests exist; the work is original, has not been accepted for publication nor is concurrently under consideration elsewhere, and will not be published elsewhere without the permission of the Editor and that all the authors have contributed directly to the planning, execution or analysis of the work reported or to the writing of the paper.

Authors’ contributions
WW and JW participated in the design of this study, and they both performed the statistical analysis. ZK and YZ carried out the study, together with WZ, collected important background information, and drafted the manuscript. HR, XC, and PW conceived of this study, and participated in the design and helped to draft the manuscript. All authors read and approved the final manuscript.

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