Treatment outcomes in humeral fractures of different location (review)

Abstract. The choice of treatment (open reduction and internal fixation) for a humeral fracture with a plate versus an intramedullary nail is highly debated. We compared outcomes (fracture union, reoperation, and adverse events) of intramedullary nailing and plate fixation in patients with proximal humeral, humeral shaft, and distal humeral fractures. No significant differences were found between intramedullary nailing and plate fixation for fracture union, reoperation, or adverse events in patients with proximal humeral or humeral shaft fractures. There is a scarcity of evidence comparing intramedullary nailing and plating for distal humeral fractures. No recommendations can be given from current evidence. Surgeons may have to continue to use discretion based on their personal preference, experience as well as patient’s characteristics and fracture features before more high-quality evidence is available.

Keywords: fracture; humerus; treatment; intramedullary nails; surgery; review

Introduction

According to Y. Akalin et al., fractures of the humerus, a common injury presenting to orthopedic surgeons, account for 1 to 3% of all fractures in the elderly and 4 to 6% in young patients [1].

The choice of open reduction and internal fixation for a humeral fracture with a plate versus an intramedullary nail is highly debated. Each treatment option has advantages. J.-G. Zhao et al. think that fixation using a plate allows direct visualization of the fracture site and facilitates the identification and protection of the radial nerve, whereas using intramedullary nailing to fix humeral fracture preserves the periosteal blood supply and minimizes the disruption of the biology of the fracture healing [2].

The aim of the present work was to determine whether the location of humeral fracture (proximal humeral, humeral shaft, and distal humeral fractures) needs to be taken into consideration when choosing between intramedullary nailing and plate fixation as the treatment option. Specifically, by searching the PubMed database, we examined the following outcomes from randomized controlled trials (RCTs) — fracture union, reoperation, and adverse events.

Proximal humeral fractures

Three RCTs (Gracitelli et al., 2016; Plath et al., 2019; Zhu et al., 2011), reporting fracture union, reoperation, and/or adverse events of intramedullary nailing and plate fixation in proximal humeral fractures, were identified from the PubMed [3–5]. Outcomes of the union as well as the reoperation and adverse events in proximal humeral fractures are presented in Tables 1 and 2, respectively. No significant differences were found between intramedullary nailing and plate fixation for fracture union, reoperation, or adverse events.

Humeral shaft fractures

Several meta-analyses (Beeres et al., 2021; Heineman et al., 2010; Wen et al., 2019; Zhao et al., 2015), comparing fracture union, reoperation, and/or adverse events for intramedullary nailing and plate fixation in humeral shaft fractures, were identified [2, 6–8]. Most of these authors have conducted meta-analyses using both RCTs and non-randomized studies of intervention.

We identified 11 eligible RCTs (Akalin et al., 2020; Bengas et al., 2014; Changulani et al., 2007; Chapman et al., 2000; Fan et al., 2015; D. Li et al., 2011; Y. Li et al., 2011;
McCormack et al., 2000; Putti et al., 2009; Wali et al., 2014; Zhang et al., 2015) from these meta-analyses and conducted quantitative analysis on fracture union, reoperation, and adverse events [1, 9–18].

Outcomes of the union as well as the reoperation and adverse events in humeral shaft fractures are presented in Tables 3 and 4, respectively. We found no significant differences between intramedullary nailing and plate fixation for fracture union, reoperation, or adverse events.

**Distal humeral fractures**

No RCT evidence comparing plating and intramedullary nailing for distal humeral fractures was identified in the PubMed database.

This is probably due to the fact that distal humeral fractures are mostly unstable, and not conducive to intramedullary nailing, so rigid plate fixation is preferred.

**Conclusions**

In this publication, we compared outcomes (fracture union, reoperation, and adverse events) of intramedullary nailing and plate fixation in patients with proximal humeral, humeral shaft, and distal humeral fractures.

Generally, our quantitative analysis using RCT evidence found that there were no significant differences between intramedullary nailing and plate fixation in terms of the fracture union, reoperation, or adverse events in patients with proximal humeral fractures or those with humeral shaft fractures (Tables 1–4). There is a scarcity of evidence comparing intramedullary nailing and plating for distal humeral fractures.

Some of our findings based on RCTs, such as the adverse events in proximal humeral fractures, were not consistent with findings from other meta-analyses synthesizing both RCTs and non-randomized studies of interventions. For example, a meta-analysis conducted by Shi et al. (2019) reported the adverse events of intramedullary nailing and locking plate used in the treatment of proximal humeral fracture by summarizing 29 individual studies, which consisted of 2 RCTs and 27 retrospective observational studies [19]. The results of the meta-analysis, which differed from our results (relative risk 1.06, 95% confidence interval 0.40 to 2.80), showed that patients who underwent intramedullary nail fixation for proximal humeral fractures were less

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**Table 1. Union in proximal humeral fractures**

| Study of subgroup | Plate | Nail | Weight, % | Risk ratio M-H, random, 95% CI |
|------------------|-------|------|-----------|-----------------------------|
|                  | Events | Total | Events | Total |                          |
| Gracitelli, 2016 | 33     | 33    | 31      | 32    | 43.6 | 1.03 [0.95; 1.12] |
| Zhu, 2011        | 25     | 25    | 26      | 26    | 56.4 | 1.00 [0.93; 1.08] |
| **Subtotal (95% CI)** | **58** | **58** | **100.0** | | **1.01 [0.96; 1.07]** |
| Total events     | 58     | 57    |          |       |          |                  |

Heterogeneity: Tau² = 0.00; Chi² = 0.32, df = 1 (P = 0.57); I² = 0 %
Test for overall effect: Z = 0.48 (P = 0.63)

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**Table 2. Reoperation and adverse events in proximal humeral fractures**

| Study of subgroup | Reoperation | Adverse events |
|------------------|-------------|----------------|
|                  | Events | Total | Events | Total | Weight, % | M-H, random, 95% CI |
| Gracitelli, 2016 | 1      | 36    | 6      | 36    | 43.6      | 0.17 [0.02; 1.32] |
| Plath, 2019      | 9      | 32    | 5      | 36    | 56.4      | 2.02 [0.76; 5.42] |
| **Subtotal (95% CI)** | **68** | **72** | **100.0** | | **0.68 [0.06; 8.42]** |
| Total events     | 10     | 11    |          |       |          |                  |

Heterogeneity: Tau² = 2.66; Chi² = 4.91, df = 1 (P = 0.03); I² = 80 %
Test for overall effect: Z = 0.30 (P = 0.77)

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**Table 3. Union in proximal humeral fractures**

| Study of subgroup | Plate | Nail | Weight, % | Risk ratio M-H, random, 95% CI |
|------------------|-------|------|-----------|-----------------------------|
|                  | Events | Total | Events | Total |                          |
| Gracitelli, 2016 | 33     | 33    | 31      | 32    | 43.6 | 1.03 [0.95; 1.12] |
| Zhu, 2011        | 25     | 25    | 26      | 26    | 56.4 | 1.00 [0.93; 1.08] |
| **Subtotal (95% CI)** | **58** | **58** | **100.0** | | **1.01 [0.96; 1.07]** |
| Total events     | 58     | 57    |          |       |          |                  |

Heterogeneity: Tau² = 0.00; Chi² = 0.32, df = 1 (P = 0.57); I² = 0 %
Test for overall effect: Z = 0.48 (P = 0.63)

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**Table 4. Reoperation and adverse events in proximal humeral fractures**

| Study of subgroup | Reoperation | Adverse events |
|------------------|-------------|----------------|
|                  | Events | Total | Events | Total | Weight, % | M-H, random, 95% CI |
| Gracitelli, 2016 | 1      | 36    | 6      | 36    | 43.6      | 0.17 [0.02; 1.32] |
| Plath, 2019      | 9      | 32    | 5      | 36    | 56.4      | 2.02 [0.76; 5.42] |
| **Subtotal (95% CI)** | **68** | **72** | **100.0** | | **0.68 [0.06; 8.42]** |
| Total events     | 10     | 11    |          |       |          |                  |

Heterogeneity: Tau² = 2.66; Chi² = 4.91, df = 1 (P = 0.03); I² = 80 %
Test for overall effect: Z = 0.30 (P = 0.77)
### Table 3. Union in humeral shaft fractures

| Study of subgroup | Plate | Nail | Weight, % | Risk ratio |
|-------------------|-------|------|-----------|------------|
|                   | Events | Total | Events | Total    |
| Akalin, 2020      | 4      | 33    | 5       | 33        | 23.8 | 0.80 [0.24; 2.72] |
| Benegas, 2007     | 0      | 14    | 0       | 11        | Not estimable |
| Benegas, 2014     | 0      | 21    | 1       | 20        | 3.6  | 0.32 [0.01; 7.38] |
| Bolano, 1995      | 1      | 14    | 4       | 14        | 8.4  | 0.25 [0.03; 1.97] |
| Changulani, 2007  | 3      | 24    | 3       | 23        | 15.9 | 0.96 [0.21; 4.27] |
| Chapman, 2000     | 3      | 46    | 3       | 38        | 15.0 | 0.83 [0.18; 3.86] |
| Fan, 2015         | 2      | 30    | 1       | 30        | 6.5  | 2.00 [0.19; 20.90] |
| McCormack, 2000   | 1      | 23    | 2       | 21        | 6.6  | 0.46 [0.04; 4.68] |
| Putti, 2009       | 1      | 18    | 0       | 16        | 3.6  | 2.68 [0.12; 61.58] |
| Wali, 2014        | 2      | 25    | 2       | 25        | 10.1 | 1.00 [0.15; 6.55] |
| Y. Li, 2011       | 2      | 22    | 1       | 23        | 6.6  | 2.09 [0.20; 21.45] |
| Zhang, 2015       | 0      | 50    | 0       | 50        | Not estimable |
| **Subtotal (95% CI)** | 320    | 304   | 100.0    | 0.85 [0.47; 1.53] |

Total events: 19 / 22

Heterogeneity: Tau² = 0.00; Chi² = 3.67, df = 9 (P = 0.93); I² = 0 %
Test for overall effect: Z = 0.55 (P = 0.58)

### Table 4. Reoperation and adverse events in humeral shaft fractures

| Study of subgroup | Plate | Nail | Weight, % | Risk ratio |
|-------------------|-------|------|-----------|------------|
|                   | Events | Total | Events | Total    |
| **Reoperation**   | 1      | 2    | 3       | 4         | 5       | 6    | 7      |
| Akalin, 2020      | 4      | 33    | 5       | 33        | 19.9   | 0.80 [0.24; 2.72] |
| Benegas, 2007     | 0      | 14    | 0       | 11        | Not estimable |
| Bolano, 1995      | 0      | 14    | 6       | 14        | 5.4    | 0.08 [0.00; 1.25] |
| Changulani, 2007  | 6      | 24    | 4       | 23        | 21.9   | 1.44 [0.47; 4.44] |
| Chapman, 2000     | 4      | 46    | 6       | 38        | 20.6   | 0.55 [0.17; 1.81] |
| D. Li, 2011       | 0      | 14    | 0       | 21        | Not estimable |
| McCormack, 2000   | 1      | 23    | 7       | 21        | 9.6    | 0.13 [0.02; 0.97] |
| Putti, 2009       | 1      | 18    | 1       | 16        | 5.8    | 0.89 [0.06; 13.08] |
| Wali, 2014        | 4      | 25    | 3       | 25        | 16.8   | 1.33 [0.33; 5.36] |
| **Subtotal (95% CI)** | 211    | 202   | 100.0    | 0.68 [0.34; 1.36] |

Total events: 20 / 32

Heterogeneity: Tau² = 0.23; Chi² = 8.25, df = 6 (P = 0.22); I² = 27 %
Test for overall effect: Z = 1.09 (P = 0.28)

| Study of subgroup | Plate | Nail | Weight, % | Risk ratio |
|-------------------|-------|------|-----------|------------|
| **Adverse events** | 6      | 33    | 6         | 33        | 11.3  | 1.00 [0.36; 2.78] |
| Benegas, 2007     | 4      | 21    | 3         | 19        | 7.5   | 1.21 [0.31; 4.71] |
| Bolano, 1995      | 1      | 14    | 4         | 14        | 3.7   | 0.25 [0.03; 1.97] |
| Changulani, 2007  | 9      | 24    | 10        | 23        | 17.5  | 0.86 [0.43; 1.73] |
| Chapman, 2000     | 20     | 46    | 22        | 38        | 24.9  | 0.75 [0.49; 1.15] |
likely to have complications than those who underwent plate fixation (odds ratio 0.75; 95% CI 0.57 to 0.97). The RCTs may be limited in terms of providing data on adverse events due to their relatively small sample size, restricted eligibility for participants, and/or limited duration of follow-up. In addition, despite our results on fracture union, reoperation, or adverse events suggesting no differences, some meta-analyses synthesizing both RCT and non-randomized studies demonstrated the superiority of intramedullary nail over plate in treating either proximal humeral fractures (Shi et al., 2019) [19] or humeral shaft fractures (Beeres et al., 2021; Wen et al., 2019) [6, 8] based on outcomes, such as intraoperative blood loss, operative time, postoperative fracture healing time, and postoperative infections.

Altogether, no strong conclusions can be drawn from current evidence. Surgeons may have discretion based on their personal preference, experience as well as patient’s and fracture features before more high-quality evidence is available.

References

1. Akalin Y. et al. Locking compression plate fixation versus intramedullary nailing of humeral shaft fractures: which one is better? A single-centre prospective randomized study. Int. Orthop. 2020. 44(10). 2113-2121. doi: 10.1007/s00264-020-04696-6.

2. Zhao J.-G. et al. Intramedullary nail versus plate fixation for humeral shaft fractures: a systematic review of overlapping meta-analyses. Medicine. 2015. 94(11). e599-e599. doi: 10.1097/MD.0000000000000599.

3. Gracitelli M.E. et al. Locking intramedullary nails compared with locking plates for two- and three-part proximal humeral surgical neck fractures: a randomized controlled trial. J. Shoulder Elbow Surg. 2016. 25(5). 695-703. doi: 10.1016/j.jse.2016.02.003.

4. Plath J.E. et al. Locking nail versus locking plate for proximal humeral fracture fixation in an elderly population: a prospective randomised controlled trial. BMC Musculoskelet. Disord. 2019. 20(1). 20. doi: 10.1186/s12891-019-2399-1.

5. Zhu Y. et al. Locking intramedullary nails and locking plates in the treatment of two-part proximal humeral surgical neck fractures: a prospective randomized trial with a minimum of three years of follow-up. J. Bone Joint Surg. Am. 2011. 93(2). 159-168. doi: 10.2106/jbjs.j.00155.

6. Beeres F.J.P. et al. Open plate fixation versus nailing for humeral shaft fractures: a meta-analysis and systematic review of randomised clinical trials and observational studies. European Journal of Trauma and Emergency Surgery. 2021. doi: 10.1007/s00068-021-01728-7.

7. Heineman D.J. et al. Plate fixation or intramedullary fixation of humeral shaft fractures. Acta Orthop. 2010. 81(2). 216-223. doi: 10.3109/17453671003635884.

8. Wen H. et al. Antegrade intramedullary nail versus plate fixation in the treatment of humeral shaft fractures: An update meta-analysis. Medicine (Baltimore). 2019. 98(46). e17952. doi: 10.1097/md.0000000000017952.

9. Benegas E. et al. Shoulder function after surgical treatment of displaced fractures of the humeral shaft: a randomized trial comparing antegrade intramedullary nailing with minimal invasive plate osteosynthesis. J. Shoulder Elbow Surg. 2014. 23(6). 767-774. doi: 10.1016/j.jse.2014.02.010.

10. Chongulani M. et al. Comparison of the use of the humerus intramedullary nail and dynamic compression plate for the management of diaphyseal fractures of the humerus. A randomised controlled study. Int. Orthop. 2007. 31(3). 391-395. doi: 10.1007/s00264-006-0200-1.

11. Chapman J.R. et al. Randomized prospective study of humeral shaft fracture fixation: intramedullary nails versus plates. J. Orthop. Trauma. 2000. 14(3). 162-166. doi: 10.1007/00068-021-01728-7.

12. Fan Y. et al. Management of humeral shaft fractures with intramedullary interlocking nail versus locking compression plate. Orthopedics. 2015. 38(9). e825-829. doi: 10.3928/01477447-20150902-62.

13. Li D. et al. Comparisons of safety and curative effect between intramedullary nail and plate for internal fixation of humeral shaft fractures. J. Jilin Univ. (Medicine Edition). 2011. 37. 342-344.

14. Li Y. et al. Postoperative malrotation of humeral shaft fracture after plating compared with intramedullary nailing. J. Shoulder Elbow Surg. 2011. 20(6). 947-954. doi: 10.1016/j.jse.2010.12.016.

15. McCormack R.G. et al. Fixation of fractures of the shaft of the humerus by dynamic compression plate or intramedullary nail. A prospective, randomised trial. J. Bone Joint Surg. Br. 2000. 82(3). 336-339. doi: 10.1302/0301-620x.82b3.9675.

16. Putti A.B. et al. Locked intramedullary nailing versus dynamic compression plating for humeral shaft fractures.
J. Orthop. Surg. (Hong Kong). 2009. 17(2). 139-141. doi: 10.1177/230949000901700202.
17. Wali M.G. et al. Internal fixation of shaft humerus fractures by dynamic compression plate or interlocking intramedullary nail: a prospective, randomised study. Strategies Trauma Limb Reconstr. 2014. 9(3). 133-140. doi: 10.1007/s11751-014-0204-0.
18. Zhang W. et al. Clinical effect comparison of locking intramedullary nail and compression plate in treatment of humeral shaft fracture. China Foreign Med. Treat. 2015. 3. 51-54.
19. Shi X. et al. Effect of intramedullary nail and locking plate in the treatment of proximal humerus fracture: an update systematic review and meta-analysis. J. Orthop. Surg. Res. 2019. 14(1). 285. doi: 10.1186/s13018-019-1345-0.

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