

RESEARCH ARTICLE

Factors Associated with Use of a Posterior Approach and Use of Minimally Invasive Plate Osteosynthesis for Plate and Screw Fixation of Middle Third Humeral Diaphysis Fracture

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Abstract

Objectives: We sought factors associated with use of a relatively unconventional use of a posterior surgical exposure and fixation for management of middle third humeral diaphysis fractures.

Methods: In a scenario-based experiment 112 surgeon participants of the Science of Variation Group (SOVG)—an international collaboration of fracture surgeons that study sources of variation in care—viewed 11 sets of radiographs of 9 middle and 2 distal third fractures of the humeral diaphysis. The primary response variable was decision to use a posterior surgical approach and fixation. The secondary response variable was additional use of a minimally invasive plate osteosynthesis (MIPO) technique. Logistic regression analysis assessed the impact of gender, continent of practice, years in practice, subspecialty, location of fellowship, volume of fractures treated per year, and location of fracture.

Results: Factors associated with recommendation of a posterior approach included 6-10 years in practice (β 0.96; 95% CI 0.55 to 1.4) and identifying as a fracture surgeon (β 0.42; 95% CI 0.06 to 0.78). Fracture location in the middle third of the humeral shaft was associated with decreased likelihood to recommend a posterior approach (β -2.2; 95% CI -2.6 to -1.7) as was practicing for 21 to 30 years (β -0.65; 95% CI -1.0 to -0.25). Factors associated with use of a MIPO technique included practicing outside of the US and Europe (β 0.91 95% CI 0.47 to 1.3) and 21-30 years of practice (β CI 0.71 95% CI 0.20 to 1.2) (all $p < 0.05$).

Conclusion: The observed association between distal third fracture location and posterior exposure for plate and screw fixation of a diaphyseal humerus fracture suggests that a posterior plate location may be a marker of relative surgeon unfamiliarity with fracture fixation surgery in this region.

Level of evidence: IV

Keywords: Fracture, Surgical approaches, Variations in care

Introduction

For plate and screw fixation of fractures of the middle third of the humeral diaphysis the anterior approach places the radial nerve at less risk than the posterior approach.¹ Claessen and colleagues studied plate fixation of humeral shaft fractures and found significantly more iatrogenic radial nerve palsy in 9 of 115 (7.8%) posterior exposures (including 32 middle third fractures for

select reasons including traumatic radial nerve palsy in 23) compared to 7 of 195 (3.6%) anterolateral exposures (all for proximal and middle third fractures), and no influence of fracture location.² A retrospective study published in 2021 comparing the two approaches for plate fixation of middle to distal third diaphyseal humerus fractures found that a 2-incision anterolateral exposure was associated with less

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bleeding, lower iatrogenic radial nerve injury rate, and better elbow function one year after surgery compared to a posterior exposure.³

Nevertheless, we occasionally see a middle third fracture treated with posterior exposure and plating. We were wondering if this is an accepted option or a marker of being outside of mainstream practices. A retrospective study of one surgeon's experience using a posterior exposure for plate and screw fixation of all diaphyseal humerus fractures found a 13% rate of iatrogenic radial nerve palsy, with lower rates as the surgeon gained experience.⁴ Posterior plate and screw fixation of distal third humeral shaft fractures is routine. But the use of posterior exposure is atypical for middle third humeral shaft fractures. While there is room for debate on many things in orthopedic surgery, some tactics are sufficiently unfamiliar and unconventional that they might, at times, be an indicator that a surgeon is outside of their area of expertise or has important knowledge gaps. For instance, use of a plate that is too short or too thin. Or fixation of the distal radius diaphysis with a dorsal plate. And perhaps fixation of the posterior humerus for a midshaft fracture.

Our primary study question was: What factors are associated with the relatively unconventional posterior exposure and posterior plate and screw fixation of the middle third of the humeral diaphysis? Our secondary study question was: What factors are associated with a minimally invasive plate osteosynthesis (MIPO) technique?

Materials and Methods

Study Design and Setting

We constructed a scenario-based experiment in which respondents were asked to review 11 sets of radiographs of diaphyseal humerus fractures (9 middle third and 2 distal third) and recommend either an anterolateral (brachialis splitting) or posterior (triceps elevating or splitting) approach for open reduction internal fixation of the fracture with plate and screw fixation using traditional technique or using a MIPO technique.

A scenario-based experiment tests associations or responses to experimental interventions. Its viability depends on a sample with sufficient variation in ratings to allow measurement of statistical associations and its results are likely reproducible in any sample with sufficient variation. A survey containing the scenarios and questions was created and distributed through SurveyMonkey (Palo Alto, CA, USA) and members of the Science of Variation Group (SOVG) were invited to participate during a three-month period in 2022. Respondents were informed that all radiographs were of a 35-year-old man, a right hand dominant, laborer. No additional patient details were provided. No nerve palsies were included. The radiographs presented were a selected set of middle to distal third

diaphyseal humerus fractures consecutively treated by a single surgeon at a Level 1 Trauma Center over a three-month period. We used the non-standarized attempts at 2 views of the fractured humerus that were used by the clinicians to treat the patients. This study was designed and reported using the STROBE guidelines and approved by the Institutional Review Board.

Participants

Members of the SOVG were invited to participate in the study. The SOVG is an international collaboration of orthopedic, plastic, and fracture surgeons that studies variation in the definition, interpretation, classification, and treatment of human illness. The SOVG provides no incentive for participation beyond group authorship. A core group of about 200 surgeons participate in at least one scenario-based experiment per year. SOVG scenario-based experiments rely on within-sample variation and randomization of multiple variables. A total of 112 surgeons completed the survey, 102 were men and the majority resided in the United States ($n = 49$) and Europe ($n = 39$) [Table 1]. Of the respondents, 48 (43%) were fracture surgeons and 86 surgeons (76%) supervised trainees [Table 1]. These demographics and practice characteristics are comparable to previous SOVG studies and the sample was sufficiently diverse.⁵⁻⁷

Table 1. Demographics of 112 participating surgeons

Variables	Value*
Men	102 (90%)
Continent of practice	
US	49 (43%)
Europe	39 (35%)
Other	25 (22%)
Location of fellowship	
United States	43 (48%)
Europe	35 (31%)
Other	23 (21%)
Years in practice	
0 to 5	26 (23%)
6 to 10	25 (22%)
11 to 20	37 (33%)
21 to 30	25 (22%)
Supervising trainees	86 (76%)
Subspecialty	
Fracture surgeon	48 (43%)
Hand and wrist	33 (29%)
Shoulder and elbow	14 (12%)
Other	18 (16%)
Humeral shaft fractures treated per year	
5 or less	43 (38%)
6 to 10	21 (19%)
11 to 20	32 (29%)
21 or more	16 (29%)

*Value is displayed as percentage (number of observations).

Response and Explanatory Variables

The primary outcome variable for the study was the plan to use a posterior surgical approach. A secondary outcome was a plan to use a MIPO technique to address the fracture. Explanatory variables were gender, continent of practice, years in practice, subspecialty, location of fellowship, volume of fractures treated per year, and location of fracture.

Statistical Analysis

Descriptive statistics were performed for all participants. Continuous variables were described with means, standard deviations and categorical variables with absolute numbers. All factors with a *P* value below 0.10 in bivariate analysis were moved into multivariate analysis. A logistic regression analysis was used to seek factors associated with the decision to use a posterior surgical approach. In a different model, a logistic regression analysis was used to seek factors associated with the decision to use a MIPO technique. All *P* values below 0.05 were considered statistically significant.

Results**Factors Associated with Recommendation for Posterior Approach**

Accounting for potential confounding using multiple logistic regression analysis, factors associated with recommendation of a posterior approach were: 6-10 years in practice (β 0.96; 95%CI 0.55 to 1.4), completing fellowship outside of the US and Europe (β 0.42; 95%CI 0.06 to 0.78), and identifying as a fracture surgeon (β 0.42; 95%CI 0.06 to 0.78). Fracture location in the middle third of the humeral shaft was associated with decreased likelihood to recommend a posterior approach (β -2.2; 95%CI -2.6 to -1.7) as was practicing for 21 to 30 years (β -0.65; 95%CI -1.0 to -0.25) (all *P* < 0.05) [Table 2]. Continent of practice, gender of surgeon, and volume of fractures treated per year were not associated.

Factors Associated with Recommendation for Minimally Invasive Plate Osteosynthesis

In multiple logistic regression analysis, factors associated with use of a MIPO technique were: practicing outside of the US and Europe (β 0.91 95%CI 0.47 to 1.3), 11-20 years of practice (β 0.54 95%CI 0.039 to 1.0), and 21-30 years of practice (β CI 0.71 95%CI 0.20 to 1.2) (all *P* < 0.05) [Table 3]. Fracture location, gender of surgeon, subspecialty, and volume of fractures treated per year were not associated.

Table 2. Multiple logistic regression analysis of factors associated with a Posterior Surgical Approach

	Regression Coefficient (95% Confidence Interval)	Standard Error	P-value
Continent			
US			

Table 2. Continued

Europe	0.34 (-0.29 to 0.98)	0.32	0.29
Other	0.13 (-0.40 to 0.66)	0.27	0.63
Years in practice			
0 to 5			
6 to 10	0.96 (0.55 to 1.4)	0.21	<0.001
11 to 20	-0.15 (-0.51 to 0.21)	0.18	0.41
21 to 30	-0.65 (-1.0 to -0.25)	0.20	0.001
Subspecialty			
Hand and wrist			
Shoulder and elbow	-0.12 (-0.55 to 0.32)	0.22	0.60
Fracture surgeon	0.42 (0.060 to 0.78)	0.18	0.022
Other	-0.20 (-0.66 to 0.25)	0.23	0.38
Location of fellowship			
US			
Europe	0.24 (-0.38 to 0.87)	0.32	0.45
Other	0.62 (0.10 to 1.1)	0.27	0.019
Fractures treated per year			
5 or less			
6 to 10	0.28 (-0.084 to 0.65)	0.19	0.13
11 to 20	-0.082 (-0.42 to 0.26)	0.17	0.64
21 or more	-0.26 (-0.70 to 0.18)	0.23	0.25
Fracture location			
Distal humerus			
Middle humerus	-2.2 (-2.6 to -1.7)	0.23	<0.001

Bold indicates statistical significance, *P* < 0.05. Factors with *P* < 0.10 in bivariate analysis were moved into negative binominal regression analysis.

Table 2. Negative binominal regression analysis of factors associated with a Minimally Invasive Plate Osteosynthesis (MIPO) approach

	Regression Coefficient (95% Confidence Interval)	Standard Error	P-value
Gender			
Female	reference value		
Male	0.89 (-0.018 to 1.8)	0.47	0.055
Continent			
US	reference value		
Europe	-0.048 (-0.51 to 0.41)	0.23	0.84
Other	0.91 (0.47 to 1.3)	0.22	<0.001
Years in practice			
0 to 5	reference value		
6 to 10	0.32 (-0.23 to 0.89)	0.29	0.26

Table 2. continued

11 to 20	0.54 (0.039 to 1.0)	0.26	0.035
21 to 30	0.71 (0.20 to 1.2)	0.26	0.007
Subspecialty			
Hand and wrist	<i>reference value</i>		
Shoulder and elbow	-0.51 (-1.2 to 0.15)	0.34	0.13
Fracture surgeon	-0.0047 (-0.48 to 0.47)	0.24	0.99
Other	0.54 (-0.0039 to 1.1)	0.28	0.052
Fractures treated per year			
5 or less	<i>reference value</i>		
6 to 10	0.22 (-0.27 to 0.72)	0.25	0.38
11 to 20	-0.18 (-0.67 to 0.30)	0.24	0.46
21 or more	0.53 (-0.010 to 1.1)	0.28	0.054
Fracture location			
Distal humerus	<i>reference value</i>		
Middle humerus	0.33 (-0.13 to 0.79)	0.23	0.16

Bold indicates statistical significance, $P < 0.05$. Factors with $P < 0.10$ in bivariate analysis were moved into negative binominal regression analysis.

Discussion

An anterior approach to the middle third of the humeral diaphysis places the radial nerve at less risk of iatrogenic injury than the posterior approach. Nevertheless, we occasionally see a middle third fracture treated with posterior exposure and plating. This study explored the factors associated with posterior exposure for plate and screw fixation of the middle to distal third of the humeral diaphysis as well as what factors are associated with use of MIPO technique. We found 6-10 years in practice, completing fellowship outside of the US and Europe, and identifying as a fracture surgeon were associated with recommendation for a posterior exposure while fracture location in the middle third of the humeral diaphysis and practicing for over twenty years was associated with recommendation for an anterior approach. Practicing outside of the US and Europe and practicing for greater than twenty years were associated with recommendation for use of MIPO technique.

This study has several limitations. First, the fractures were retrieved from a single surgeon at a single Level 1 trauma center tertiary hospital, which could limit generalizability. For instance, there were relatively few distal third fractures (only 2) compared to the typical percentage, with published rates of 46% middle third humeral diaphysis fracture compared to 20% distal third humerus fractures.⁸ And having only 2 distal third fractures may have altered the statistical analysis. Second, most SOVG participants work in an academic setting (76% supervise trainees) and their

values, training, and practice might differ from the larger community of surgeons. Given that the intention was to test if use of a posterior exposure for a middle third fracture was a potential marker of concern, this might not be the best cohort in which to try to discern quality indicators. Third, only 20% of respondents practice outside of the US and Europe, and this relatively small sample may not be representative of practice patterns in these locations. Fourth, we did not account for fracture pattern due to the limited number of images. Some surgeons might consider fracture pattern when making treatment recommendations. Fifth, some surgeons may prefer an intramedullary nail and we did not track this as a potential explanatory variable. Sixth, the study depends on the large number of participants and observations, but the relatively small number of fractures may not adequately represent variations based on fracture patterns. Seventh, a scenario-based study cannot account for the nuances of the care of individual patients. Nevertheless, such studies have been able to measure meaningful associations and it seems likely that the greater complexity of actual patient interactions might enhance the findings compared to this relatively artificial setup. Finally, our study does not provide any information on education and training of participants.

Factors Associated with Recommendation for Posterior Approach

The finding of recommendation of an anterolateral exposure for middle third fractures with small variations based on surgeon characteristics confirmed our sense that most surgeons would rather limit dissection of the radial nerve when possible. For a middle third fracture, the radial nerve is generally not in harm's way with an anterolateral exposure, making plate and screw fixation easier and safer. Iatrogenic radial nerve palsy is associated with a posterior surgical approach, which is more often used for fractures that extend close to the olecranon fossa. Radial nerve palsy with an anterolateral approach is more common when the exposure and fixation extend distally, near the coronoid and radial fossae, where the radial nerve runs anteriorly and is at risk. There are few studies documenting routine use of a posterior exposure for a middle third fracture of the humerus and one was from Korea.^{4,9} This, along with our finding that completing a fellowship outside of the US and Europe was associated with a recommendation to utilize a posterior approach may indicate some regional variations. In our opinion, the relative avoidance of a posterior approach and fixation for a middle third fracture of the humerus is consistent with general training and recommendations. Our data supports that posterior plate fixation of midshaft humerus fractures is relatively unconventional and might, at times, be an indicator that a surgeon is operating outside of their comfort zone.

Factors Associated with Recommendation for

minimally Invasive Plate Osteosynthesis

The observation that utilizing minimally invasive plate osteosynthesis (MIPO) was also associated with non-US, non-European practice location and longer duration of practice suggests that this technique may also be used by a specific subset of surgeons and may vary geographically and culturally. The espoused advantages of MIPO technique include better preservation of the biologic environment of the fracture zone, which portends minimal disruption of fracture callous as well as a low documented risk of iatrogenic radial nerve injury.¹⁰ Perils of MIPO include lack of visualization of neurovascular structures, which are intimate to the fracture zone in the middle third of the humeral diaphysis, and obtaining and maintaining adequate fracture reduction.¹¹ A recent systematic review and meta-analysis identified a 5% pooled risk difference in secondary radial nerve palsy and nonunion rate in favor of MIPO over traditional plating technique but did not identify a significant difference between techniques in infection, time to union, re-intervention, operation duration, functional shoulder scores, and functional elbow scores. The authors comment that the secondary radial nerve palsies were transient with both plating techniques.¹² The results of this study aligned with findings of a prior metanalysis.¹¹ The observation that the six randomized control trials to date addressing MIPO compared to open exposure were performed in China, Korea, Egypt, Iran, and Brazil aligns with our finding that continent of practice is associated with recommendation for use of MIPO.¹³⁻¹⁷

Conclusion

The observation that distal third fracture location was the factor most strongly associated with posterior exposure for plate and screw fixation of a diaphyseal humerus fracture suggests that surgeons tend to prioritize function of the radial nerve. The finding that surgeons favor an anterolateral and open exposure of middle third diaphyseal humerus fractures, with some geographic and generational variations, suggests that a posterior approach to exposure and fixation of a diaphyseal humerus fracture is relatively unconventional. Advocates of a posterior approach to middle third diaphyseal fractures of the humerus can

perform experiments to test for potential benefits that balance the known risks to the radial nerve.

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Authors Contribution:

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References

1. Zlotolow DA, Catalano I, Louis WI, Barron OA, Glickel SZ. Surgical Exposures of the Humerus. J Am Acad Orthop Surg. 2006;14(13):754-765.
2. Claessen FMAP, Peters RM, Verbeek DO, Helfet DL, Ring D. Factors associated with radial nerve palsy after operative treatment of diaphyseal humeral shaft fractures. J Shoulder Elbow Surg. 2015;24(11):e307-e311. doi:10.1016/j.jse.2015.07.012.
3. Huang Q, Lu Y, Wang ZM, et al. Anterolateral approach with two incisions versus posterior median approach in the treatment of middle- and distal-third humeral shaft fractures. J Orthop Surg Res. 2021;16(1):197. doi:10.1186/s13018-021-02355-z.
4. Lee WY, Shin HD, Kim KC, Cha SM, Jeon YS.

- Relationship between incidence of postoperative radial nerve palsy and surgical experience in the treatment of humeral shaft fractures through a posterior triceps splitting approach: A retrospective study. *AOTT*. 2021;55(4):338-343. doi:10.5152/j.aott.2021.20415.
5. Kyriakedes JC, Crijns TJ, Teunis T, Ring D, Bafus BT. International Survey: Factors Associated With Operative Treatment of Distal Radius Fractures and Implications for the American Academy of Orthopaedic Surgeons' Appropriate Use Criteria. *J Orthop Trauma*. 2019;33(10):e394-e402.
 6. Crijns TJ, Kortlever JTP, Guitton TG, Ring D, Barron GC. Symptoms of Burnout Among Surgeons Are Correlated with a Higher Incidence of Perceived Medical Errors. *HSS J*. 2020;16(2_suppl):305-310.
 7. Mellema JJ, Janssen S, Schouten T, et al. Intramedullary nailing versus sliding hip screw for A1 and A2 trochanteric hip fractures: what factors influence surgeons' choice of implant? *Bone Joint J*. 2021;103-B(4):775-781. doi:10.1302/0301-620X.103B.BJJ-2020-1490.R1.
 8. Mattila H, Kesitalo T, Simons T, Ibounig T, Rämö L. Epidemiology of 936 humeral shaft fractures in a large Finnish trauma center. *J Shoulder Elbow Surg*. 2023;32(5):e206-e215. doi:10.1016/j.jse.2022.10.020.
 9. Gausden EB, Christ AB, Warner SJ, Levack A, Nellestein A, Lorch DG. The triceps-sparing posterior approach to plating humeral shaft fractures results in a high rate of union and low incidence of complications. *Arch Orthop Trauma Surg*. 2016;136(12):1683-1689. doi:10.1007/s00402-016-2578-6.
 10. Tetsworth K, Hohmann E, Glatt V. Minimally Invasive Plate Osteosynthesis of Humeral Shaft Fractures: Current State of the Art. *JAAOS*. 2018;26(18):652. doi:10.5435/JAAOS-D-17-00238.
 11. Hohmann E, Glatt V, Tetsworth K. Minimally invasive plating versus either open reduction and plate fixation or intramedullary nailing of humeral shaft fractures: a systematic review and meta-analysis of randomized controlled trials. *J Shoulder Elbow Surg*. 2016;25(10):1634-1642. doi:10.1016/j.jse.2016.05.014.
 12. Beeres FJ, Diwersi N, Houwert MR, et al. ORIF versus MIPO for humeral shaft fractures: a meta-analysis and systematic review of randomized clinical trials and observational studies. *Injury*. 2021;52(4):653-663. doi:10.1016/j.injury.2020.11.016.
 13. Matsunaga FT, Tamaoki MJS, Matsumoto MH, Netto NA, Faloppa F, Belloti JC. Minimally Invasive Osteosynthesis with a Bridge Plate Versus a Functional Brace for Humeral Shaft Fractures: A Randomized Controlled Trial. *JBJS*. 2017;99(7):583. doi:10.2106/JBJS.16.00628.
 14. Esmailiejah AA, Abbasian MR, Safdari F, Ashoori K. Treatment of Humeral Shaft Fractures: Minimally Invasive Plate Osteosynthesis Versus Open Reduction and Internal Fixation. *Trauma Mon*. 2015;20(3):e26271. doi:10.5812/traumamon.26271v2.
 15. Hadhoud M, Darwish A, Mesriga MK. Minimally invasive plate osteosynthesis versus open reduction and plate fixation of humeral shaft fractures. *Menoufia Med J*. 2015;28(1):154. doi:10.4103/1110-2098.155974.
 16. Kim JW, Oh CW, Byun YS, Kim JJ, Park KC. A Prospective Randomized Study of Operative Treatment for Noncomminuted Humeral Shaft Fractures: Conventional Open Plating Versus Minimal Invasive Plate Osteosynthesis. *J Orthop Trauma*. 2015;29(4):189. doi:10.1097/BOT.0000000000000232.
 17. Lian K, Wang L, Lin D, Chen Z. Minimally Invasive Plating Osteosynthesis for Mid-distal Third Humeral Shaft Fractures. *Orthopedics*. 2013;36(8):e1025-e1032. doi:10.3928/01477447-20130724-18.