Review Article

Concept of neutral rotation sling for non-operative treatment of proximal humerus fractures

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Abstract: Proximal humerus fractures (PHFs) are common injuries and are most frequently treated non-operatively. Non-operative management has shown adequate results in the majority of PHF with appropriate patient selection. However, a uniformly agreed upon protocol for non-operative treatment of PHFs does not currently exist. A review of the literature demonstrates a wide range of immobilization devices, immobilization time, and physical therapy protocols. Non-operatively treated PHFs are frequently treated in a commercially available sling that holds the humeral shaft in a relatively internally rotated position in relation to the humeral head, potentially displacing the fracture. Surgical neck fractures may heal in a position with the humeral shaft relatively internally rotated in reference to the humeral head. Additionally, greater tuberosity fractures may heal with more posterior displacement in reference to the humeral head when the arm is immobilized in internal rotation. Placing patients in a neutral rotation shoulder immobilizer better maintains alignment in PHFs, thus reducing the risk of potential malunion. Justification for immobilization in a neutral rotation sling for non-operative treatment of PHFs is proposed in this review. Furthermore, this article reviews immobilization and physical therapy treatments in order to suggest a standardized, evidence-based protocol for non-operative management of PHFs.

Keywords: Proximal humerus fracture (PHF); sling; neutral rotation; non-operative

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Introduction

Proximal humerus fractures (PHFs) are a common source of morbidity in patients, especially in the elderly population. It is the third most common fracture diagnosed in elderly patients after hip and distal forearm fractures (1). PHFs most commonly occur from a low energy mechanism such as a fall from standing height. These fractures are more common in females (84%) and elderly patients with an average age of 71 years (2). While extremely common, up to 84% of PHFs are treated conservatively without surgery (3). The proportion of PHF being treated conservatively has remained relatively unchanged in the past decade. In that same timeframe, open reduction and internal fixation (ORIF) was the most common type of surgery for PHFs. Shoulder replacement procedures are another surgical option, with recent emphasis on reverse shoulder arthroplasty (RSA), which has largely replaced hemiarthroplasty (HA) (4).

Surgery has traditionally been reserved for displaced two, three, and four-part PHFs based on the classic Neer criteria (5). Although the rate at which PHFs are being treated with surgery has not changed, there has been recent literature supporting non-operative treatment in displaced PHFs. The Proximal Fracture of the Humerus Evaluation by Randomization (PROFHER) study was a multi-center randomized study conducted in the United Kingdom comparing surgical and non-surgical treatment in 250 patients with displaced surgical neck fractures of the proximal humerus. The study found no difference in function outcomes, quality of life scores, complication rates, or mortality at two and five years post-injury (6,7). Furthermore, two recent Cochrane systematic review showed no evidence of improved functional or quality of life scores in operatively treated displaced PHFs (8,9).

A uniform protocol for suggested non-operative treatment of PHFs does not currently exist. A wide range of timeframes for immobilization exist. The duration, frequency, and type of physical therapy also varies significantly in the literature. When assessing the type of immobilization used, most commonly it is a routine sling with the arm resting in an internally rotated position. The potential exists for malreduction of the PHF from remaining in this position. In this article, we introduce the concept of immobilization of PHFs in neutral rotation. Furthermore, we offer a comprehensive review of non-operative protocols used in the literature, and propose a standardized protocol for non-operative treatment of these injuries.

Neutral rotation immobilization

The method of shoulder immobilization in PHFs may influence fracture healing and ultimately shoulder function. Few studies have compared different types of shoulder immobilizers. Rommens *et al.* compared the Gilchrist arm sling to a Desault bandage, finding better patient satisfaction with the Gilchrist arm sling but no difference in functional results (10). Both forms of immobilization hold the arm in internal rotation and neither is widely used in practice today. The standard of care in many medical centers is immobilization in a commercially available simple sling. While this is a cost-effective option for shoulder immobilization, standard slings typically hold the arm in an internally rotated position.

No studies to date have directly compared outcomes in PHF treated nonoperatively in a neutral rotation sling versus a standard internal rotation sling. However, a recent randomized controlled trial found that neutral rotation slings provided improved external rotation, adduction, and pain after anatomic total shoulder arthroplasty (11). Similarly, improved motion and pain has been shown in patients with rotator cuff repairs treated with neutral rotation braces (11). While it is unrealistic to extrapolate these results to nonoperatively treated PHFs, literature has shown that immobilization of a post-insult shoulder in neutral rotation many times leads to earlier improved motion and pain.

An intact rotator cuff balances the humeral head in a neutral position with the supraspinatus, infraspinatus, and teres minor muscles directing an external rotation force and the subscapularis muscle countering with an internal rotation force. Collectively, this maintains the humeral head centered on the glenoid in a neutral rotation. The pectoralis major and latissimus dorsi muscles produce an internal rotation and adduction force on the proximal humeral shaft, while the deltoid produces a superior directed force. In the setting of a surgical neck fracture of the proximal humerus, the humeral head and its rotator cuff attachments are effectively separated from the humeral shaft. In this scenario, the humeral head is held in a neutral position regardless of the position of the humeral shaft. Therefore, if the arm is in a standard sling, the humeral shaft will be relatively internally rotated with respect to the humeral head resulting in fracture malreduction. This phenomenon has been illustrated radiographically in *Figure 1*.

PHFs that involve an isolated greater tuberosity fracture or a three-part fracture with greater tuberosity involvement, have similar malreduction forces that may lead to malreduction of the fracture. The posterior rotator cuff muscles create a force vector that pulls the tuberosity fragment medially and posteriorly. If the arm is held in an internally rotated position, the remaining humeral head and shaft displace from the greater tuberosity fragment. If the humeral shaft is held in a neutral position, this force is decreased, improving the alignment of the fracture (*Figure 2*).

The theory that maintaining the arm a neutral rotation would better align PHFs was examined with a cadaveric model (*Figure 3*). The cadaveric specimens were dissected down to the intact rotator cuff. In the first specimen, one pin was driven into the humeral head and one in the humeral shaft. A surgical neck osteotomy was then performed to simulate a surgical neck fracture. As seen in *Figure 3A*, when the arm is held in internal rotation, the fracture displaces due to the rotator cuff maintaining the humeral head in a neutral orientation. When the arm is held in neutral rotation the fracture is well reduced. A greater tuberosity osteotomy was performed on another specimen, simulating an isolated greater tuberosity fracture. With the arm internally rotated, the fracture displaces posteriorly and with the arm in neutral the fracture is well reduced (*Figure 3B*). Fracture displacement also occurs with an isolated greater

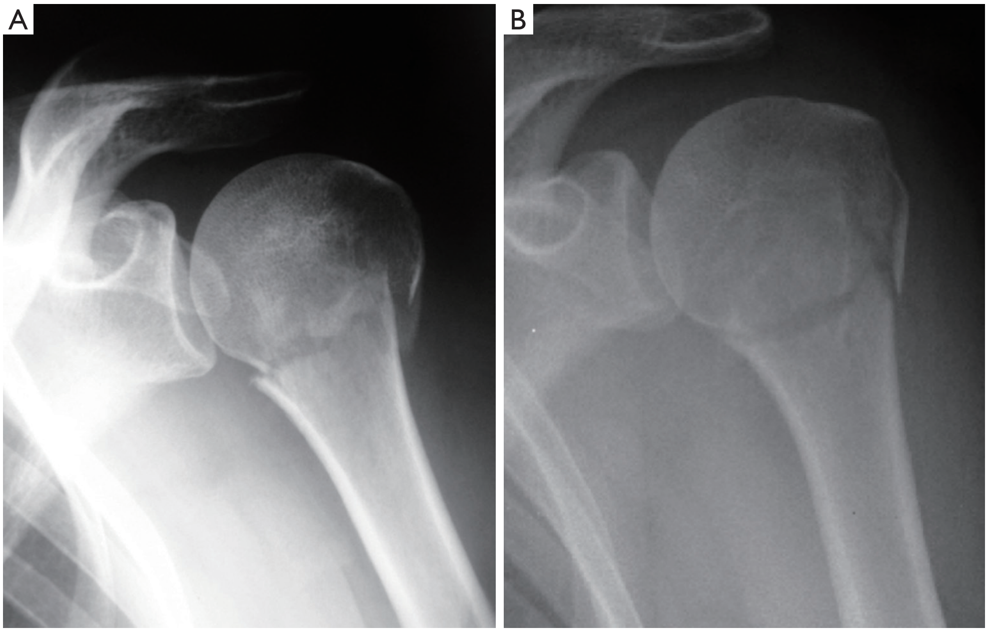

Figure 1 AP radiographs of a surgical neck type PHF. The arm held in a standard sling (A) demonstrates fracture malalignment compared to the arm in a neutral rotation immobilizer (B).

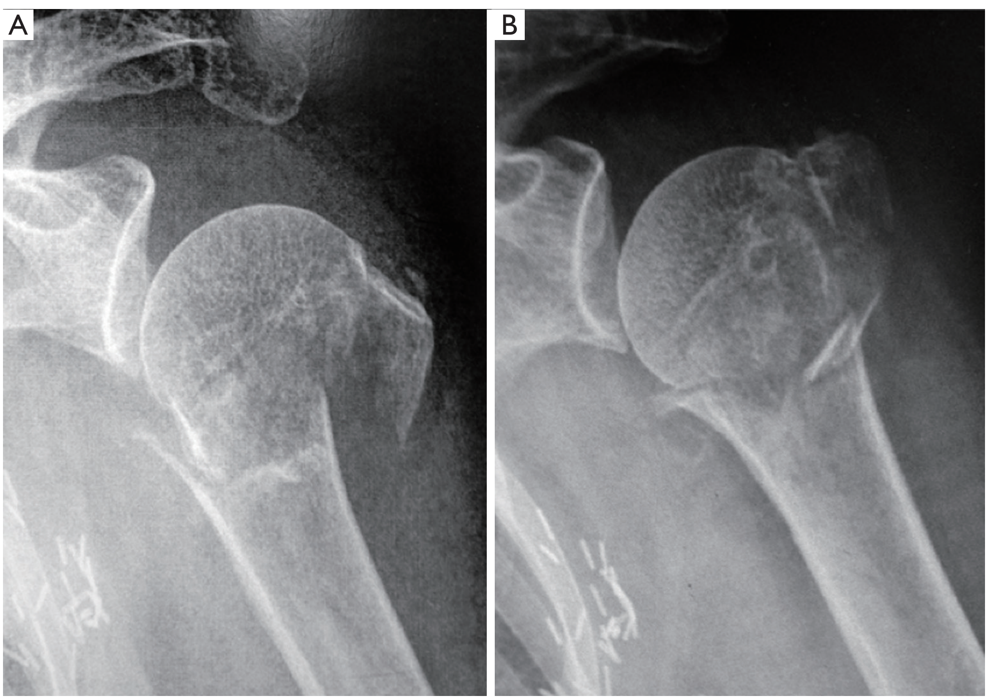

Figure 2 AP radiographs of a three part PHF with surgical neck and greater tuberosity components. The arm held in a standard sling (A) demonstrates malalignment of both the surgical neck and greater tuberosity components compared to the arm in a neutral rotation immobilizer (B).

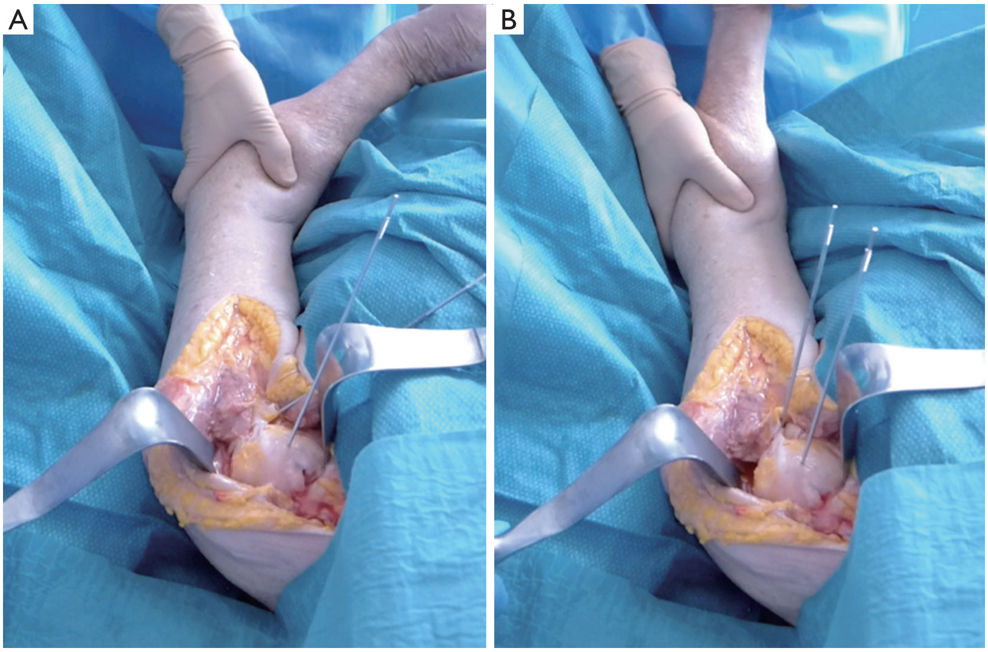

Figure 3 A cadaveric specimen with a surgical neck osteotomy shows rotational displacement with the arm in internal rotation (A), and acceptable alignment with the arm in neutral rotation (B).

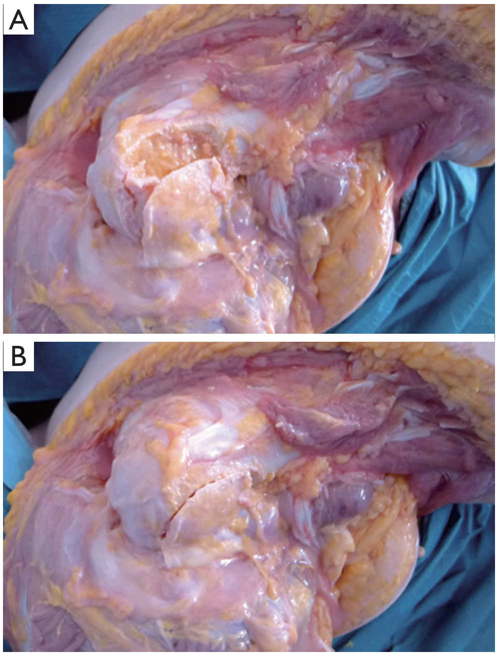

Figure 4 A cadaveric specimen with a greater tuberosity osteotomy shows fragment displacement with the arm in internal rotation (A) when compared to neutral rotation (B).

tuberosity osteotomy on a cadaveric model as shown in *Figure 4*. While a cadaveric specimen cannot account for the dynamic forces experienced in the shoulder, PHFs appear to maintain a more anatomic fracture alignment when the arm is held in a neutral rotation as opposed to internal rotation.

Length of immobilization

The length of time for shoulder immobilization varies significantly between providers. A search of rehabilitation protocols for non-operatively treated PHFs in the past twenty years demonstrates a range of time for shoulder immobilization. The protocols range from zero to four weeks of strict immobilization time, with two weeks being the most common length of time (*Table 1*).

With a shorter immobilization period, patients will theoretically have a faster recovery time but risk fracture displacement. With prolonged immobilization periods, patients theoretically have a lower risk of fracture displacement but are at risk of shoulder stiffness and slower return to function. Hodgson *et al.* compared immediate mobilization with physical therapy to delayed mobilization

Table 1 Summary of studies reviewing non-operative treatment of proximal humerus fractures, highlighting length of immobilization, time until passive range of motion allowed, and time until active range of motion allowed

Study	N	Length initial immobilization	Time until passive motion	Time until active motion
Zyto, 1997 (12)	15	7–10 days		
Hodgson, 2003 (13)	44	<1 week	<1 week	4 weeks
Hodgson, 2003 (13)	42	3 weeks	3 weeks	7 weeks
Lefevre-Colau, 2007 (14)	32	<72 hours	<72 hours	6 weeks
Lefevre-Colau, 2007 (14)	32	3 weeks	3 weeks	6 weeks
Fjalestad, 2010 (15)	25	2 weeks	2 weeks	
Olerud, 2011 (16)	29	2 weeks	2 weeks	4 weeks
Olerud, 2011 (17)	25	2 weeks	2 weeks	4 weeks
Yüksel, 2011 (18)	18	2 weeks	2 weeks	6 weeks
Boons, 2012 (19)	25	0 weeks	0 weeks	6 weeks
Hauschild, 2013 (20)	31	1 week	1 week	
Foruria, 2015 (21)	93	2 weeks	2 weeks	12 weeks
Rangan, 2015 (6)	109	3 weeks		
Carbone, 2017 (22)	36	7 days	7 days	3 weeks
Carbone, 2017 (22)	39	7 days	7 days	3 weeks
Fang, 2017 (23)	7	4 weeks	4 weeks	4 weeks
Granade, 2017 (24)	19	2 weeks	2 weeks	6 weeks

for three weeks in a randomized controlled trial. The authors found that patients with earlier mobilization had better pain and functional scores at 16 weeks post-injury but no statistical difference at one year (13). Lefevre-Colau *et al.* also compared early mobilization to delayed mobilization in a randomized controlled trial. The early mobilization group started physical therapy within 72 hours of the injury with passive range of motion and pendulum exercises with the other group delaying any mobilization for three weeks. The study found improved function and pain at six weeks and three months in the early mobilization group but no significant difference at six months post-injury (14). These randomized controlled trials suggest that early mobilization after a PHF will improve function and pain in patients in the early rehabilitation period but may affect the long-term outcome.

Physical therapy and home exercise protocols

The literature demonstrates variability in rehabilitation protocols for non-operatively treated PHFs. Most protocols entail a period of immobilization followed sequentially by passive range of motion exercises, active range of motion exercises, and finally strengthening exercises. Home exercise programs have been shown to be as effective as formal physical therapy when performed correctly (25). Most providers agree that a structured early rehabilitation program produces better results as has been shown in the literature (8).

Table 1 also highlights the timeframe that patients with a PHF were allowed to begin passive and active range of motion exercises in select protocols for conservatively treated PHFs. The median time until passive range of motion was allowed was two weeks and for active motion was six weeks. Carbone *et al.* recently compared early intensive mobilization to early conventional mobilization. Both groups started physiotherapy seven days after the injury with the intensive mobilization group starting pendulum exercises and assisted passive motion exercises five times a week for two weeks, followed by active motion three weeks post-injury. The conventional group did physical therapy sessions twice a week. This study found no advantage to early intensive mobilization (22).

Conclusions

A consensus on treatment protocol for non-operatively treated PHFs does not exist. The routine placement of PHFs in a standard sling keeps the humeral shaft internally rotated relative to the humeral head, causing potential displacement and malunion of the fracture. We propose that PHFs treated without surgery be placed in a neutral rotation shoulder immobilizer at the time of injury. We also encourage a standard rehabilitation protocol that includes pendulum and gentle range of motion exercises for the first two weeks after the injury. This is followed by two weeks of passive range of motion exercises, then two weeks of active range of motion exercises, and progression to full activity without restrictions at six weeks. A randomized controlled trial comparing results in patients with a standard sling and patients in a neutral shoulder immobilizer is necessary to further evaluate this proposal.

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Footnote

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