

The "suture-only" fixation in the treatment of proximal humerus fractures: A narrative review

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Abstract

Introduction: Surgical treatment of proximal humerus fractures (PHFs) is still associated with high complication and reoperation rates, most of them being implant related. In order to reduce such complications, a minimally-invasive technique was introduced by using only sutures for fixation of PHFs.

Methods: For the arrangement of this narrative non-systematic review, an exploratory search in the MEDLINE (via PubMed) database using the keywords "proximal humeral fracture" and "sutures" was conducted.

Results: The initial search in Pubmed yielded 254 studies, where only 8 were found to be possibly relevant. Following critical review, there were 6 studies that satisfied the inclusion criteria and were subject to further analysis. There were 325 patients with PHFs included in our study. The average age was 58 years (range 18–84 years). By fracture type there were 79 (24.3%) two-part greater tuberosity (GT) fractures with 36 (46%) of them associated with anterior dislocation, 9 (2.8%) two-part surgical neck (SN) fractures, 114 (35.1%) three-part fractures, and 124 (38.2%) four-part fractures, all of them being valgus impacted type.

Conclusion: The "suture-only" technique obtains good clinical outcomes with lower complication and reoperation rates, but in selected types of unstable PHFs: two-part GT fractures with or without associated shoulder dislocation, and three- and four-part valgus-impacted fractures. While the indications for two-part SN fractures are contradictory, three- and four-part varus fractures, four-part fracture dislocations and split fractures are contraindicated for "suture-only" fixation. However, additional studies with a higher level of evidence are necessary to support the routine use of the "suture-only" technique in the treatment of these selected types of PHFs.

Keywords

Proximal humeral fractures, Transosseous sutures, Surgical treatment

Introduction

Proximal humerus fractures (PHFs) currently account for approximately 5% of all fractures and 53% of all shoulder girdle injuries [1]. In patients older than 65 years, their incidence is ranked third, following distal radius and femoral neck fractures [2–4]. Although most of these fractures can be treated nonoperatively [5], the expected increase in their incidence will likely result in a higher number of corresponding surgical procedures [2,3]. Among the variety of existing

fixation techniques (percutaneous pinning, intramedullary (IM) nailing [6], arthroplasty replacement [7] and the gold standard – locking plates (LPs) [8] with or without different types of augmentation [9]), in recent years, several authors report good results when using only sutures for fixation in selected types of unstable PHFs [10–15]. The potential benefits of this attractive tension band technique are the minimal soft tissue dissection, diminishing the chance for humeral head avascular necrosis (AVN) and infection, and the mini-

mized complications related to the implant, such as: implant migration (reported in the percutaneous pinning); screw penetration through the humeral head and subacromial impingement (SAI) (mainly related to LP and IM fixation).

The current article provides an overview of the available literature for fixation of unstable two-, three- and four-part PHFs with the use of absorbable and non-absorbable sutures only. The latter are discussed in detail.

Materials and methods

For the arrangement of this narrative non-systematic review, an exploratory search in the MEDLINE (via PubMed) database using the keywords “proximal humeral fracture” and “sutures” was conducted. The search was originally performed in August 2024 to include the most recent literature. The selected studies were limited to English only. The results of the search were critically evaluated and clinical studies were included in a detailed review. Reference lists from the articles retrieved were further examined to identify any additional studies of interest. Inclusion criteria for the study were: proximal humerus fractures due to trauma; patients older than 18 years of age; more than 10 patients included in the study; at least 12 months follow up; studies with patients or subgroups having three or four-part PHFs. Exclusion criteria considered: patients younger 18 years of age; studies with less than 10 included patients; studies with patient follow-up of less than 12 months.

Results

The initial search in Pubmed yielded 254 studies, where only 8 were found to be possibly relevant. Following critical review, there were six studies that satisfied the inclusion criteria and were subject to further analysis. All six studies included for analysis can be classified as level IV evidence case series based on the Centre for Evidence-Based Medicine published guidelines. One study was performed prospectively^[13] while the other five studies were conducted retrospectively.

There were 325 patients with PHFs in the six included studies. The average age was 58 years (range 18–84 years). The average follow-up was 60.2 months (range 12–38 months). By fracture type, there were 79 (24.3%) two-part greater tuberosity (GT) fractures with 36 (46%) of them associated with anterior dislocation, 9 (2.8%) two-part surgical neck (SN) fractures, 114 (35.1%) three-part fractures, and 124 (38.2%) four-part fractures, all of them being valgus impacted type.

In two out of the six selected studies, the deltopectoral approach was used^[14,15]; in another two of the studies, the trans-deltoid approach was used^[12,13]; and in the remaining two studies, both approaches were used^[10,11]. One author used number 2 non-absorbable polyester sutures^[10], 4 authors used number 5 non-absorbable Ethibond sutures^[12–15]. Only one author used number 2 absorbable (Vicryl) sutures^[11].

Despite some variation, the usual technique of suture fixation included one pair of sutures passing transosseously through the lesser tuberosity and/or through the tendon of the subscapularis muscle, and one pair of sutures through the greater tuberosity and/or through the posterior rotator cuff tendons^[12]. Two pairs of transosseous sutures passed lateral and medial through the articular fragment, proximally from the fracture line. Another two pairs of sutures were inserted laterally and medially through 2.7-mm or 2.5-mm drill holes in the diaphysis. These sutures were directed into the opposite tuberosity, near the musculotendinous junction, and onto the neighboring area of the articular segment (i.e., through the medial aspect of the diaphysis toward the greater tuberosity and through the lateral aspect of the diaphysis toward the lesser tuberosity, as well as to the adjacent articular fragment). Once all sutures were in place, the tuberosities were approximated to the diaphysis, just below the top of the humeral head fragment (Fig. 1).

The postoperative rehabilitation protocol differed slightly between the studies. One author didn't describe their postoperative rehabilitation protocol^[10]. The other authors used a three-phased rehabilitation program with pendulum exercises beginning at the second postoperative day. Passive-assisted exercises started in the second–third or fourth–sixth postoperative weeks, followed by active assisted exercises and strength recovery.

The authors who described their postoperative follow-up protocols followed a standard radiological schedule at the first, third, sixth, and twelfth month after surgery^[10,12]. Shoulder function was clinically examined after the sixth week of rehabilitation^[10,12,13,14,15].

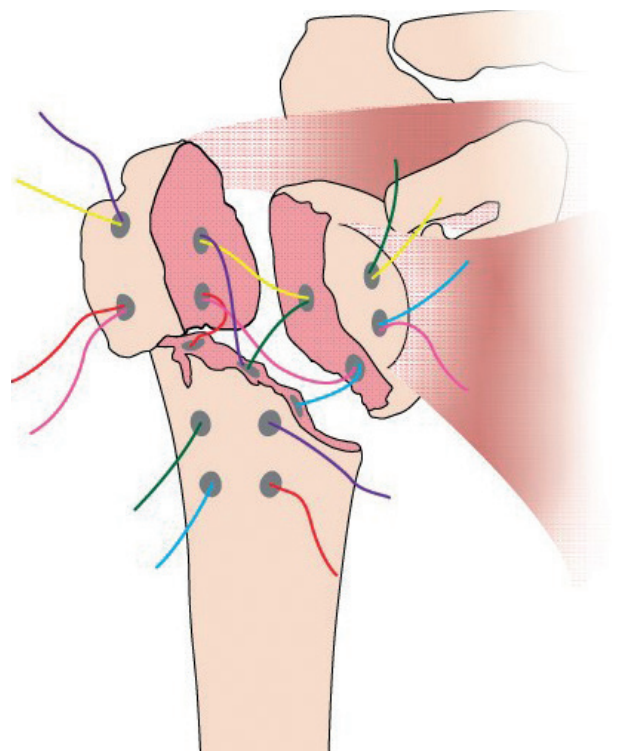


Figure 1. Schematic representation of “suture-only” technique in three-part PHF.

Table 1. Results and complications for the studies using "suture-only" PHF fixations.

Author, year	Number of patients	Mean Age (years)	Mean follow-up (months)	Fracture type/Neer	Suture type	Functional outcome	Complications/re-interventions - in number of patients
Park, 2003 [10]	27 (28 shoulders)	64	53	13 (two-part GT*) 9 (two-part SN*) 6 (three-part)	no. 2 non-absorbable polyester	ASES score: Excellent (22 patients) Satisfactory (3 patients) Unsatisfactory (3 patients)	Deep infection - 1 Adhesive capsulitis - 1 Re-interventions - 1
Hocking, 2003 [11]	11	55	69	four-part valgus impacted	no. 2 absorbable sutures (Vicryl)	CMS ^{indiv} * - 86	AVN* - 1
Dimakopoulos, 2007 [12]	165	54	65	56 (two-part) 64 (three-part) 45 (four-part valgus impacted)	no. 5 non-absorbable sutures (Ethibond)	CMS* - 91	Malunion - 9 AVN - 11 SAI* - 4 Posttraumatic OA* - 2 Re-interventions - 7
Panagopoulos, 2018 [13]	49	60	44	four-part valgus impacted	no. 5 non-absorbable sutures (Ethibond)	CMS ^{indiv} * - 86.2	Nonunion - 1 AVN - 3 AVN of GT* - 5 Re-interventions - 4
Miquel, 2021 [15]	64	58	58	10 (two-part GT*) 22 (three-part) 14 (four-part valgus impacted)	no. 5 non-absorbable sutures (Ethibond)	CMS - 69	AVN - 9 Re-interventions - 4
Scheer, 2021 [14]	27	66	72	22 (three-part valgus impacted) 5 (four-part valgus impacted)	no. 5 non-absorbable sutures (Ethibond)	CMS - 63 CMS ^{indiv} * - 81 Oxford Shoulder Score - 45	AVN - 6 AVN of GT - 2

AVN* – avascular necrosis; GT* – greater tuberosity; CMS* – Constant-Murley Score; CMS^{indiv}* - individual Constant-Murley Score calculated as the percentage of the CMS with regard to the contralateral shoulder of the patient; SAI* – subacromial impingement; OA* - osteoarthritis.

Constant-Murley Score was used for functional evaluation in 5 out of 6 studies. The average Constant Score at the final follow-up for the patients who had undergone open reduction and transosseous suture fixation was 78.2 (range 63–91). In two studies, the reported Constant Score was stratified by fracture type, being least for four-part fractures and greatest for two-part fractures [12,15].

There was a total of 48 (14.8%) reported clinically relevant complications and 16 (4.9%) re-interventions.

The results and complications for each separate study are detailed in Table 1.

Discussion

Despite the advantages of the newer generations of implants, the results of the operative treatment for unstable PHFs are still associated with high complication and reoperation rates [8,16]. A recent systematic review and meta-analysis reported a 23.8% complications and 10.5 % of re-interventions rates when LP was used for fixation in unstable PHFs [17]. The systematic review of Wong et al. [6] showed a complication rate of 41.5 % when third generation IM nail was used. The reported rate of pin migration with the method of closed reduction and percutaneous pinning ranges from 19 to 40 % [18,19].

Suturing the tubercles and/or the rotator cuff's tendons with non-absorbable sutures to the LP is a well known technique for counterbalancing the tendons' muscles, resulting in a lower risk of fragments displacement [20]. The sutures

diverge proximally from the plate to the greater and lesser tubercles, forming a structure resembling an open parachute [20]. The anatomical reduction of the tubercles secures the anatomical reduction of the humeral head and its height, which maintains a lever arm for the rotator cuff mechanism to work efficiently and reverses any residual varus deformity of the humeral head reduction [20,21]. Also, sutures can be used as a tool for manipulating tubercles' fragments during their reduction [22].

Using non-absorbable sutures in PHFs fixation is based on the biomechanical estimations that the average load to failure, depending on knot type for all braided non-absorbable polyblend suture, is well over 100 N [23]. The incorporation of multiple sutures, therefore, should theoretically counter the natural effect of the rotator cuff which has been estimated to be at least 340 N in terms of force [23].

Aside from using sutures as a reduction tool and supplement to the LP and IM fixation, several authors reported good results when applying the tension band principles using only sutures for fixation [10–15]. The tension band neutralizes the deforming forces that the rotator cuff exerts on the tubercles and the bending moments on the level of the surgical neck. This forms a load-sharing construction, transforming the tension forces on the surface of the proximal humerus into compression forces between the fragments and stimulating fracture healing [21].

The majority of authors using "suture-only" fixation report good clinical outcomes and low complication and reoperation rates, but in selected PHF types. Most of the authors recommend the technique for two-part GT frac-

tures, two-part SN fractures, and three- and four-part valgus-impacted fractures. Only Dimakopoulos et al. [12] do not recommend the technique for two-part SN fractures as the authors believe that there is a rotational instability with an unstable fixation between the large proximal fragment and the narrow diaphysis that is a predisposition for further displacement. On the other hand, Park et al. [10] report that patients with two-part SN fractures treated with sutures have outcomes similar to patients treated with two-part GT fractures. The authors using the “suture-only” technique for three- and four-part valgus-impacted fractures explain their good results on the basis of the fracture morphology described by Jacobs et al. [24]: a subtype of proximal humeral fractures, where the articular segment is impacted into the metaphysis, causing spread of the greater and/or lesser tuberosities and thus creating a fracture line through the anatomical neck with minimal or zero disruption of the posteromedial hinge. In this impacted type of fractures the authors don't recommend disimpacting the articular head fragment from its valgus position during fracture reduction in order to minimize the risk of further disruption of the posteromedial hinge and the posteromedial artery that supplies the humeral head [12,14,15]. While all authors recommend the technique for valgus-impacted fractures, in their study with the largest patients cohort, Dimakopoulos et al. [12] indicate that four-part valgus-impacted fractures with more than 7 mm translation and more than 45° impaction angle are contraindicated for transosseous suture fixation. For three-part varus-displaced PHFs Miquel et al. [15] found significantly worse clinical outcomes comparing them with valgus- and neutral-angle displaced fractures. The authors claim that fractures demonstrating varus malalignment are more likely to disrupt the medial soft tissue sleeve and are more likely to be unstable with different fixation techniques. As a consequence, Miquel et al. [15] do not recommend the osteosuture technique for patients presented with three-part varus-displaced fractures. The latter is in line with the findings of other authors [25] who also report that a preoperative varus displacement is a strong predictor of unsatisfactory outcomes and loss of fixation [16,26,27]. Miquel et al. [15] were also unable to reproduce the good clinical results obtained by the other authors for four-part valgus-impacted fractures and recommend the transosseous suture technique for such fractures only in biologically young patients.

Despite its lower incidence, some complications related to the ‘suture-only’ technique can be prevented or at least detected early, as described by some authors. Stiffness and restricted shoulder motion, suggestive of adhesive capsulitis, are more common in patients who do not adhere to the rehabilitation protocol. SAI can result from migration, flattening of the greater tuberosity, or malunion of the humeral head - signs that are visible radiographically. Clinically, SAI can be diagnosed with a positive Neer test, a painful arc of abduction, or a drop arm sign [12]. Absorption of the great-

er tuberosity is typically observed between the third and fourth months postoperatively and does not significantly compromise shoulder function. Panagopoulos et al. suggest that one possible cause of greater tuberosity absorption is the intraoperative over-pulling of the tuberosities by the surgeon while attempting to retract the greater tuberosity below the level of the humeral head [13]. Humeral-head AVN is characterized by the destruction of trabecular architecture and loss of osseous substance in the articular segment. Although multifactorial, this complication is most strongly associated with fracture type and inadequate postoperative reduction [12, 15].

In general, all authors using the “suture-only” technique report good clinical results, mostly related to the low complication rate. Despite the severe displacement, adequate fracture stability can be achieved by simple osteosynthesis with “tension band effect” and adequate rotator cuff repair, which is sufficient to allow early passive joint motion and good outcomes for the majority of patients [11,14]. The technique is minimally invasive, with less soft-tissue dissection, shorter operative time and low rate of AVN and osteoarthritis [11-14]. Hardware-associated complications such as screw penetration into the glenohumeral joint and discomfort from bulky implants (mainly SAI) which otherwise may call for reoperations, are obviated with the “suture-only” fixation [10,11,14,15].

The present study has some limitations. First, it was limited by its narrative design, which may have introduced selection bias. Second, the number of included studies was relatively small. Third, the studies included in the final analysis were level IV of evidence, and further research with higher levels of evidence is needed to confirm these findings. However, this study also has several strengths. One strength is the strict inclusion criteria used, which helped minimize potential bias. Another strength is the large total number of patients, which is adequate for a meaningful analysis of the results. Lastly, the mean follow-up period in the included studies is sufficient to objectively assess functional outcomes and detect any subsequent complications.

Conclusion

The “suture-only” technique obtains good clinical outcomes with lower complication and reoperation rates, but in selected types of unstable PHFs: two-part GT fractures with or without associated shoulder dislocation, and three- and four-part valgus-impacted fractures. While the indications for two-part SN fractures are contradictory, three- and four-part varus fractures, four-part fracture dislocations and split fractures are contraindicated for “suture-only” fixation. However, additional studies with a higher level of evidence are necessary to support the routine use of the “suture-only” technique in the treatment of these selected types of PHFs.

Additional information

Conflict of interest

The author has declared that no competing interests exist.

Ethical statements

The authors declared that no clinical trials were used in the present study.

The authors declared that no experiments on humans or human tissues were performed for the present study.

The authors declared that no informed consent was obtained from the humans, donors or donors' representatives participating in the study.

The authors declared that no experiments on animals were performed for the present study.

The authors declared that no commercially available immortalised human and animal cell lines were used in the present study.

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Author contributions

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Data availability

All of the data that support the findings of this study are available in the main text.

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