ABSTRACT • Current algorithms for decision making in proximal humerus fractures consider the fracture pattern along with the patient characteristics and surgeon’s experience. Minimally invasive techniques for reduction and internal fixation of many types of these fractures have recently been widely promoted, especially with the use of the newly developed locking plate systems. Intramedullary flexible nailing is one of the oldest techniques using minimally invasive reduction and fixation of proximal humerus fractures. Kapandji technique uses the “Deltoid V” landmark as entry point for intramedullary insertion of the flexible nails into the humeral head. The authors report their experience with this procedure in twenty-six, relatively young patients with good bone quality, presenting with displaced 2- or 3-part extra-articular fracture of the proximal humerus, treated with percutaneous reduction and intramedullary flexible nailing as described by Kapandji. Nineteen medical records were available for this retrospective review, with 9 to 12 months follow-up. There were 15 excellent and 1 good results when patients were assessed for pain, function and range of motion of the shoulder. The authors submit that Kapandji technique is a valuable procedure for management of extra-articular displaced 2- and 3-part proximal humerus fractures in young patients with good bone quality.

Keywords: proximal humerus fractures; minimally invasive osteosynthesis; intramedullary flexible fixation; Kapandji technique

INTRODUCTION

Conventional open techniques for reduction and internal fixation of proximal humerus fractures are classically performed through a delto-pectoral approach [1-3]; however, they are notorious for stripping of soft tissues, which jeopardize the vascular supply of the humeral head [2, 3]. The sub-acromial lateral deltidoid split approach is currently frequently used for minimally invasive reduction and locking plate fixation of these fractures [4-6]. Maneuvers for fracture reduction through this approach have been developed, and are at present widely reported in the literature [5-8]. Minimally invasive techniques cause less risk to the vascularity of the humeral head, and the use of locking plates has shown advantages with respect to fracture stabilization, especially in osteoporotic bone [5-11]. Nevertheless, relatively high rates of complications and revision surgery are still observed with locking plate fixation; they are mainly related to technical and indication pitfalls [12, 13]. Methods for minimally invasive intramedullary flexible nailing fixation of proximal humerus fractures have been well-described in the literature, suggesting different entry points for the insertion of the flexible nails [14-23]. Kapandji technique uses the “Deltoid V” at the lateral aspect of the humerus for nail insertion [20, 22]. The aim of this study is to retrospectively evaluate the anatomic and functional results of the Kapandji technique in selected cases of two- and three-part fractures of the proximal humerus.

KAPANDJI TECHNIQUE AS A MINIMALLY INVASIVE PROCEDURE FOR SELECTED PATIENTS WITH TWO- AND THREE-PART FRACTURES OF THE PROXIMAL HUMERUS


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MATERIAL AND METHODS

The authors carried out a retrospective review of the medical records and X-rays of patients treated for displaced proximal humerus fracture with the Kapandji technique [20, 22], between December 2002 and January 2015. During the same period, other patients received open reduction and internal fixation using plate and screws, or hemiarthroplasty, when indicated; they are not included in this review.

The indication for employing the Kapandji technique was restricted to the following criteria: good bone quality as judged by X-rays, displaced surgical neck fracture with or without fracture of the greater tuberosity, a fracture pattern judged to be amenable to reduction by external maneuvers, and the absence of associated gleno-humeral dislocation. All fractures were extra-articular and sorted into the category of “sub-tuberosities” fractures according to the French classification of Duparc [24]; they all had 2 or 3 fragments according to Neer’s classification [25]. The fracture was considered to be displaced when it showed a shaft-head displacement of more than 50% of the diaphyseal diameter, a humeral head varus or valgus angulation of more than 20-30°, or a greater tuberosity displacement of more than 2-5 mm in any direction, as suggested by many authors [26-28].

There were a total of 26 patients who fulfilled these criteria. Seven records were dropped because of lack of one or more of the following information: clinical assessment at the final follow-up, initial X-rays at the time of injury, or final X-rays at bone consolidation. As a result, the final number of records that were included and analyzed in this study was 19. There were 15 female and 4 male patients aged between 16 to 59 years, with a mean age of 45 years at the time of fracture. The right side was affected in 11 patients and the left side in 8. The fracture was closed in 18 patients, and in one patient there was an open comminuted surgical neck fracture secondary to gunshot injury, without neurovascular involvement. Sixteen fractures, including the open fracture, were initially classified as 2-part fractures. The remaining 3 fractures were classified as 3-part fractures with associated displaced fractures of the surgical neck and greater tuberosity. Among the 16 patients classified as 2-part fractures, 4 patients initially had an associated undisplaced greater tuberosity fracture as seen on preoperative X-rays. One of these 4 patients was reclassified as a 3-part fracture because of intraoperative displacement of the initially undisplaced greater tuberosity fracture. Accordingly, our series consisted of 15 patients with a 2-part fracture and 4 patients with a 3-part fracture.

All patients were operated within 1 to 5 days of the injury, using the same surgical technique as previously described by Kapandji and detailed below [20, 22]. All patients were immobilized with an arm sling for 2 to 3 weeks after surgery. They all underwent immediate postoperative elbow and wrist mobilization. Shoulder rehabilitation was started 2 weeks following surgery, according to the following protocol: controlled pendulum exercises for one week, passive shoulder motion for 2 weeks, assisted active shoulder motion as tolerated for 2 weeks followed by active motion for 2 weeks after assessment of bone healing. Rehabilitation was then continued as needed to restore muscles strength and full range of motion as possible. Removal of hardware was performed under sedation between 3 and 6 months after fixation, the nails being directly palpable under the skin.

Regular follow-up at one-month intervals was done with radiographic and clinical assessment until hardware removal, then at around 3-month intervals and up to 9 to 12 months post-fixation. At final follow-up, patients were evaluated for pain and range of motion of their shoulder, elbow, wrist and hand, in comparison to the opposite side. The result was considered excellent when there was recovery of full range of motion on physical exam with absence of any shoulder pain; good result meant that the patient complained of mild pain during heavy work, but had full range of motion on physical exam, without limitation of daily activities; lastly, the result was considered bad if the patient reported pain during daily activities or had any limitation of shoulder mobility on physical exam as compared to the opposite side.

Surgical technique

All patients were operated under general anesthesia in a semi-setting position, with the forearm resting on an arm board. Intraoperative C-arm fluoroscopy was used in all patients to assess reduction and fixation. The surgical procedure generally followed the description initially reported by Kapandji [20, 22]. The patient’s shoulder is positioned on the edge of the table, and the proper position of the C-arm checked for by antero-posterior and axillary views before sterile draping of the entire upper limb. A 5 cm longitudinal skin incision was made at the tip of the distal insertion of the deltoid muscle on the lateral aspect of the arm, at the junction of the proximal and middle third of the humerus. The incision was carried down to bone through the distal fibers of the deltoid muscle. The cortex was opened using a bone awl oriented perpendicular to the humerus; a 4.5 mm drill bit was introduced into the medullary canal and directed 45° cephalad toward the proximal humeral medullary canal. The hole was then fashioned into an oval or a pear shape contour in order to make it approximately 2 cm long and 0.5 cm wide; a small bone rongeur was used to achieve this, with caution not to weaken the humeral shaft at the entry point. Particular care was made to achieve anatomic reduction as assessed by fluoroscopy. Reduction of the surgical neck fracture was achieved by external maneuvers. In some of our patients, surgical tricks through a separate lateral sub-acromial deltoid split approach, as previously described by many authors [4-10], were used to maximize the quality of reduction, especially in irreducible varus or valgus displacement; they consisted of percutaneous joystick or elevation maneuvers applied to the humeral head, or rotation maneuver into the humeral head of the first inserted intramedullary nail. Long Kirschner wires of 20/10 diameter were used as flexible nails for A.H. CHAMSEDDINE et al. – Kapandji technique for proximal humerus fractures Lebanese Medical Journal 2016 • Vol 64 (3) 169
A total of two to four nails were used as needed, depending on the diameter of the canal and the intraoperative post-
fixation’s stability as judged by fluoroscopy; the proximal
end of the nails should ideally be divergent into the humer-
al head at the end of fixation on fluoroscopic AP and axillary
views. Lastly, the distal end of the nails were bent at right
angle, and cut back 1 to 2 cm from the lateral cortex and
buried into the surrounding soft tissues at the time of closure.
After fixation of the surgical neck fracture, additional direct
reduction of the greater tuberosity was performed when
indicated through a lateral deltoid split approach; fixation of
the greater tuberosity was then performed using one or two
4.0 mm cancellous screws with washers.

RESULTS

In all but one patient, fracture healing was achieved in
anatomic or near anatomic alignment within 2-3 months
postoperatively, as assessed by X-ray control. The one
patient with an open comminuted surgical neck fracture
progressed into non-union, with absence of signs of cal-
lus formation at 6 months postoperatively. The fracture
was subsequently managed by open reduction and internal
fixation using plate and screws, with autologous iliac
bone graft; this case was judged to be a technical failure.

At the final follow-up, elbow, wrist and hand were
pain free with unrestricted range of motion as compared
to the opposite side in all 18 patients with healed fracture.
Excellent result was achieved in 15 patients, with com-
plete absence of shoulder pain and full range of motion as
compared to the opposite side; they were all less than 50
years old at the time of trauma and had either 2-part frac-
tures (13 patients), or 3-part fractures (2 patients). One
46-year-old patient with 3-part fracture was evaluated as
having a good result because he reported mild pain on
heavy work, but with full range of motion and no limi-
tation of daily activities. Finally, one patient with a 2-part
fracture and another with a 3-part fracture ended up hav-
ing bad results; they both reported pain during daily
activities and 5-15° limitation of the range of motion in
forward elevation, external rotation and internal rotation
of the gleno-humeral joint; they were both > 50 years old
and had prior history of “rotator cuff tendinosis.”

DISCUSSION

In 1970, Neer [25] adopted the concept of four frag-
ments of proximal humerus fractures that was first sug-
gested by Codman in 1934 [29]; the fracture can produce
any possible combination of four potential fragments:
the humeral head, the humeral shaft, the greater tuber-
osity, and the lesser tuberosity. Irrespective to the number
of fracture lines, Neer defined the criteria for fragment
displacement that would warrant surgical treatment as
being 45° angular deviation or 1 cm displacement [25].

Many authors suggested revision of Neer’s criteria to
include lesser acceptable degrees of displacement [26-
28]. In addition, Neer’s classification does not clearly
distinguish fractures of the surgical neck from those of
the anatomic neck; these two types of fractures have dif-
ferent prognosis with regard to eventual development of
avascular necrosis related to interruption of humeral
head vascularity [24]. In the French classification of
Duparc [24], the so-called “sub-tuberosities” fractures
constitute the most common fractures of the proximal
humerus; they consist of fractures of the surgical neck,
with or without a fracture of the greater tuberosity or,
less frequently, the lesser tuberosity. These fractures, previously described by Kocher in the German literature [30], are extra-articular and exhibit only a minimal risk for avascular necrosis because the articular capsule remains attached to the humeral head fragment [24].

Different methods of intramedullary flexible nailing (IMFN) have been reported for proximal humerus fractures; they differ from one another according to the entry point of the nails into the medullary canal of the humerus. In 1968, Appril and Boll [14] reported the retrograde IMFN for surgical neck fractures of the humerus starting from the posterior olecranon fossa of the distal humerus; this approach had previously been described by Hackethal in 1961 for fixation of humeral shaft fractures [31]. In 1978, Vichard [17] described the retrograde bipolar elastic nailing using a double approach from both medial and lateral epicondyles. IMFN from only the lateral epicondyle [15] or the medial epicondyle [16] was also used. In 1989, Kapandji [20] reported on the treatment of surgical neck fractures of the humerus using IMFN from the “Deltoid V” located at the junction between the proximal and middle third of the humerus. Although satisfactory results are not directly related to the choice of the entry point, the results seem to more depend on the number of nails inserted into the medullary canal [19]; however, the number per se is not a main issue as it may differ according to the diameter and compliance of the canal itself [32]. The most important tips of the technique are: achieve percutaneous anatomic reduction of the fracture, fill the canal with flexible nails, assure locking the nails into it, and give different directions of the proximal ends of the nails into the humeral head [22]. Faithful application of these surgical details usually gives satisfactory stability to the construct and maintenance of the reduction in selected cases of 2- and 3-part fractures of the proximal humerus [22, 32]. We believe, like many others, that main factor for success of this method of fixation is fundamentally correlated with proper patient selection, based on a decision making algorithm [33].

To choose a particular method of treatment for each case, one should meticulously consider the fracture’s type and geometry (such as direction of the fracture lines, number of fragments, comminution, and degree of displacement), along with the unique characteristics of each patient (such as age, bone quality, associated co-morbidities, and noncompliance); finally, and above all, the surgeon’s experience plays a fundamental role all the way from the radiographic analysis to the implementation of treatment [33].

Our indications for Kapandji technique are selective and restricted to patients presenting with displaced extra-articular surgical neck fracture with or without associated displaced fracture of the greater tuberosity and which are thought to be amenable to closed or percutaneous reduction, with good bone quality of the humeral head, and absence of associated gleno-humeral dislocation. Fractures of the anatomic neck with thin or short proximal fragment, and fractures in osteoporotic bone, offer poor purchase for the flexible nails into the humeral head; we believe these two situations constitute absolute contraindication to this procedure. The amount of head-shaft initial displacement or varus-valgus angulation did not influence the quality of intraoperative reduction in our patients; anatomic reduction was always possible by external maneuvers (Figures 1 & 2). Additional joystick or elevation maneuvers applied to the proximal fragment, and rotational manipulations of the first flexible nail that is introduced into the humeral head, were used in some cases to maximize head-shaft reduction as needed. However we believe that these maneuvers should always be used with caution as they may create an empty space into the humeral head with subsequent poor initial fixation or secondary loss of fixation, especially when bone quality

**Figure 2.** A 2-part fracture with valgus angulation and head-shaft displacement > 50% on (a) antero-posterior and (b) lateral transthoracic radiographs. Immediate postoperative (c) antero-posterior and (d) transthoracic radiographs. Note that the fracture healing is achieved without impairment of the initial reduction despite the minimal distal migration of the flexible nails on (e) antero-posterior and (f) transthoracic views.
is questionable or borderline. We insist on the fact that the presence of good bone quality is a prerequisite for the use of this technique, as it is an important predictor of the purchase of the flexible nails into the humeral head, and hence for the postoperative maintenance of reduction and ultimate stability of the final construct. Associated displaced fractures of the greater tuberosity impair the function of the rotator cuff and may induce impingement by the sub-acromial arch \[34\]; separate treatment of this fracture is mandatory and crucial for restoration of rotator cuff function. Direct approach with anatomic reduction and stable fixation of the greater tuberosity can safely be done through a lateral sub-acromial deltoid split approach \[4-9\]. However, the deltoid split should respect the anatomic landmark of the anterior branch of the axillary nerve as it runs 5 to 7 cm distal to the lateral edge of the acromion at the deep aspect of the deltoid muscle \[9, 35\]. After reduction of the greater tuberosity, its fixation can be performed with trans-osseous sutures at the tendon-bone junction with tension band effect \[34, 36, 37\], and direct multiple pins \[19, 34\] or screws \[36, 37\]. The size of the greater tuberosity fracture was sufficiently adequate to allow insertion of screws in all four cases of 3-part fracture in this series (Figure 3).

Complications have been variably reported in the literature with different techniques of IMFN for 2- and 3-part fractures of the proximal humerus. Some authors observed complications related to the location of the entry point. The trans-tricipital supra-olecranon approach has been observed to interfere with elbow motion as it may create irritation of the distal triceps tendon and adhesion to the posterior aspect of the distal humerus \[32\].

The lateral and medial epicondylar approaches may induce skin irritation as the nails remain proud in the thin subcutaneous tissue at the lateral and medial aspects of the elbow, and the medial epicondylar approach may pose a threat to the ulnar nerve as well as its irritation by the nail \[32\]. We believe both approaches may also limit elbow function because of painful reaction secondary to soft tissues irritation.

In the “Deltoid V” approach, promoted by Kapandji, the distal end of the flexible nails are well embedded into relatively thick soft tissues; they also remain distant from the elbow joint and its surrounding tendons, and from any neurovascular structure, as the radial nerve traverses the lateral inter-muscular septum around 6 cm distal to the entry point \[22\]. None of our patients developed radial nerve paralysis. However, Kapandji reported two cases of radial nerve paralysis in a series of 38 patients; both resolved within 6 months, after removal of the nails in addition to neurolysis in one of them \[22\]. He stated that this complication should not be seen as long as the technical steps are faithfully followed and anatomical landmarks for the entry point are respected; use of Hohman retractors to expose the entry point is prohibited. Wide trephining may weaken the bone and may lead to subsequent iatrogenic humeral fracture regardless of the location of the entry point \[21, 38\].

Proximal migration of the flexible nails into the sub-acromial bursa with perforation of the humeral head has also been reported with all methods of IMFN \[18, 22, 23\], and is attributed to the use of the technique in osteoporotic bone \[22, 32\]. None of our patients developed any of these two complications.

Although non-union was absent in Kapandji’s series \[22\], it was very rarely observed in other reports on IMFN for proximal humerus fractures, and was attributed to either a persistent fragment displacement \[18\], or
to an erroneous indication such as the use of the method in 4-part fractures and osteoporotic bone [19, 32]. The only case of non-union in our series is probably related to wrong indication; we believe the IMFN failed to restore bony contact as well as sufficient stability at the site of comminution located just below the surgical neck fracture; this issue has also been emphasized by others [34].

Since anatomic reduction was achieved in all other patients, bad functional results in two patients of this elective series seem to be related to age above 50 years and to the presence of previous rotator cuff disease.

CONCLUSION

We believe that meticulous patient selection and restricted indications are of primary importance to achieve satisfactory results with the use of Kapandji technique in proximal humerus fractures. We advise using this technique in extra-articular fractures with 2 or 3 fragments, in young patients with good bone quality of the humeral head.

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