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Original Article

Does K-wire position in tension band wiring of olecranon fractures affect its complications and removal of metal rate?

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ABSTRACT

Background: Despite the recognised complications of migration of wires and soft tissue irritation, tension band wiring (TBW) remains the gold standard for fixation of displaced, minimally comminuted olecranon fractures. There is much variation in placement of the K-wires with current AO guidance stating that each wire should be drilled through the anterior cortex and then backed up by 1 cm. The aim of this study was to examine the effect of K-wire position (intramedullary vs. transcortical) on stability of the construct and significant local complications.

Methods: All patients who underwent TBW for an isolated olecranon fracture in our trauma unit between 1/1/2009 and 31/12/2011 were included in this retrospective study. Mean follow-up was 14 months (range 5–29 months). Data was gathered from medical records and radiographs. The outcome measured was removal of metal due to complications such as wound problems or proximal migration of wires as standard practice within our trauma unit. **Results:** Sixty-three patients met the inclusion criteria. Forty-seven had an intramedullary compared with 16 with transcortical configuration (ratio 3:1). Nine patients (19%) with intramedullary K-wires required removal of metalwork – seven due to prominent metalwork and two with wound infection. Four patients (25%) with transcortical K-wires required removal of metalwork – three due to prominent metalwork and one with failure of metalwork. There was no significant statistical difference between transcortical and intramedullary K-wire placement with regards to complication rates following tension band wiring of an isolated olecranon fracture requiring removal of metal (Chi squared test with Yates' correction $p = 0.89$).

Conclusion: We concluded that we found no difference in complications or metalwork removal rate in the placement of K-wire in tension band wiring for isolated olecranon fracture. We recognise our study was limited by small numbers and is based on the experience of one trauma unit.

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1. Background

Olecranon fractures are common injuries of the proximal ulna which constitute about 10% of all upper extremity injuries.¹ Olecranon fractures are usually isolated and displaced, requiring operative treatment to facilitate fracture healing and restoration of elbow function. However, there may be other associated lesions such as radial head/neck fracture and dislocation that occur with olecranon fractures. This is most commonly found in complex injuries and poly-trauma cases.^{2,3} Due to the intra-articular extension of fractures, anatomic reduction and early mobilisation should be achieved in any case.⁴ It is known that only undisplaced fractures (5% of total) are treated conservatively while displaced fractures (95% of total) are subjected to operative treatment.^{4–6}

Tension band wiring (TBW) which was introduced by Weber and Vasey⁷ remains the most widespread method for fracture fixation in isolated olecranon fractures.^{8–10} The principles of tension band wiring in olecranon fracture are conversion of tensile forces on the posterior side of the olecranon into compression forces at the joint line. In the olecranon, the figure-of-eight wire loop acts as a tension band during flexion of the elbow. Multifragmentary olecranon fractures cannot be fixed with tension band wiring. In order to be able to use tension band wiring as treatment of olecranon fracture, the anterior cortex cannot be comminuted and must provide a buttress to allow compression. The figure-of-eight wire loop lies on the posterior surface of the olecranon and acts as a tension band when tightened.

However, a number of complications such as infection, non-union, malunion and ulnar nerve palsy could compromise the effect of operative treatment in up to 10% of cases.^{11–13} Moreover, the subcutaneous placement of K-wires and their potential migration may be responsible for local pain, secondary displacement and wound healing problems.¹⁴ Despite the recognised complications of migration of K-wires and soft tissue irritation, tension band wiring (TBW) remains the gold standard for fixation of displaced, minimally comminuted olecranon fractures.

There is much variation in the placement of the Kirschner wires (K-wires) in TBW. Current AO guidance states that K-wire in TBW should be placed in transcortical configuration. K-wire should be drilled through the anterior cortex and then backed up by 1 cm in order to reduce complications such as iatrogenic neurovascular damage and irritation to soft tissues. Despite the AO teaching, some surgeons do advocate placing the K-wire in intramedullary configuration in tension band wiring. Their argument is that they feel there is no difference in the back out rate of K-wire, less chance of injury to the neurovascular bundle and minimising the operation time especially in the frail elderly group.

The purpose of this study was to determine the clinical and radiological outcome after tension band wiring of olecranon fractures and to record the incidence of hardware removal and disability arising from this treatment modality. Our hypothesis is that there is no difference in the complications and removal of metal rate in both technique of K-wires placement in tension band wiring (Figs. 1 and 2).

2. Methods

Between 2009 and 2011 inclusive, 174 patients with elbow injuries presented to the emergency department in our district general hospital. Most of them were referred and subsequently admitted to our trauma unit for surgical intervention to their elbow injuries. These patients had a wide range of variation in their injuries such as elbow dislocation; isolated or complex elbow fractures and distal humerus fracture. All elbow injuries were coded under the same category in the database by the fracture outcome research unit in our trauma unit when patients were admitted for surgical intervention. All patients' demographic were identified from the database stored within the fracture outcome research unit. We identified all these patients that underwent surgical intervention coded under elbow injury by the fracture outcome research unit.

The inclusion criteria for this study were isolated olecranon fracture and underwent tension band wiring as treatment. Exclusion criteria were severe concomitant or complex injuries of elbow, those that underwent plate osteosynthesis or conservative management. An isolated olecranon fracture without severe concomitant or complex injuries of the affected elbow was identified in 63 patients. All of them were suitable for inclusion into the study. All 63 patients were able to be identified for further follow-up from their fracture clinic dictation notes and follow-up X-rays. A questionnaire was devised for data collection for this study. Telephone survey was carried out to determine the effectiveness of this treatment modality and its complications. Ethical approval was sought and approved by the local ethic committee for the purpose of this study.

The fracture pattern was assessed using the Mayo classification⁴ which takes into account the degree of fracture displacement and comminution as well as the stability of the elbow joint (Fig. 3).

The surgical procedure for tension band wiring was carried out by positioning the patient in a supine position on the

Fig. 1 – Intramedullary placement of K-wire in TBW.

Fig. 2 – Transcortical placement of K-wire in TBW.

fracture table. The anaesthetist in our trauma unit carried out the anaesthetic technique under general, regional or combination of both for this procedure. All cases were performed under the supervision of consultant orthopaedic surgeon. One dose of intravenous antibiotic (flucloxacilin or teicoplanin if penicillin allergy or MRSA positive) was given during induction of anaesthesia as per trust protocol prior to inflation of tourniquet. Tourniquet was inflated at 250 mm Hg as norm in our trauma unit for upper limb injuries.

The fracture site was approached via a posterior midline skin incision. In each case, the ulnar nerve was identified with palpation but neither its release nor its transposition was primarily performed. Fracture osteosynthesis was achieved with the insertion of two parallel 1.6 mm Kirschner wires (K-wires) from the tip of the olecranon and an 18 gauge wire in a figure-of-eight fashion. K-wires were positioned either in an intramedullary or transcortical configuration subject to operating surgeon's preference. Major intraoperative goal in the transcortical method was the perforation of the ulnar anterior cortex in an effort to increase fixation stability and to minimize pin migration.

In both techniques, the proximal end of K-wires was bent and the cerclage wire was placed through a predrilled transverse hole in the distal fragment and under the triceps tendon. Subsequently, the cerclage wire was tightened to create interfragmentary compression. One or two-knot technique of tightening was utilised according to surgeon's preference. The entire process was done under fluoroscopic guidance. Intraoperative result was considered acceptable when less than 2 mm intra-articular gap or displacement was apparent.

The postoperative protocol included neurovascular status monitoring and progressive mobilisation of the elbow joint from day one after surgery if fracture fixation is deemed stable. No further antibiotics were required postoperatively as per trust protocol unless it's an open fracture. In cases of fracture comminution (Types IIB) a posterior splint with the elbow in a semi-flexed position was applied for a period of 2–3 weeks with the aim to prevent fracture collapse and displacement.

Anteroposterior and lateral elbow radiographs were repeated at regular intervals in fracture clinic appointment

until evidence of union was detected. All patients were followed-up in fracture clinic for further assessment with respect to the purpose of the study. Flexion–extension arc of the elbow and pronation–supination arc of the forearm were measured with a goniometer to determine their motion arc after surgical intervention. The duration of follow-up for this study ranged from 5 to 29 months (mean 14 months).

Patient-rated outcomes evaluated with the Mayo Elbow Performance Score (MEPS), Visual Analogue Scale (VAS) subjective pain score (10 = unbearable pain) and VAS patient satisfaction score (10 = complete satisfaction).² Degenerative changes were described as the presence of at least one of the following radiological signs: subchondral cysts, subchondral sclerosis or osteophytes (separate or together).⁸

3. Statistics

The Microsoft Excel program was used for the creation of the graphs and the SPSS program 12.0 (SPSS Inc, Chicago, IL, USA) for the creation of statistics. Data analysis was conducted with Chi square test (with Yates' correction). *p*-Values less than 0.05 were considered to be statistically significant.

4. Results

From the total of 63 patients who were included in the study, there were 28 men and 35 women (Fig. 4) with a mean age of 58 years (range from 20 to 95 years) (Fig. 5). The frequency of fractures was higher in men until the 5th decade of life but altered in older decades towards women. The left elbow was affected in 33 patients (52.3%) and the right in 30 patients (47.6%). Regarding the mechanism of injury, slip or simple fall onto the arm were responsible for 29 fractures. In the remaining cases, the fractures were a result of a high energy trauma, such as fall from height or road accident.

According to Mayo classification for olecranon fractures, the distribution of lesions was as follows: 48 Type IIA (76%) and 15 Type IIB (24%). The average period of hospitalisation was 3.7 days (median = 2; min = 1, max = 10). We included Mayo type IIA and type IIB for the purpose of this study as we were concentrating mostly in the tension band wiring technique and its complications rate. Mayo type IIIA/IIIB is likely to undergo internal fixation with locking or non-locking plate in our trauma unit due to the comminution nature or associated injuries. Thus, the logic for choosing only these two groups of patient were made prior to the study and agreed as the most appropriate by consultant colleagues.

During the period of study, 47 K-wires were positioned in intramedullary configuration as compared with 16 transcortical K-wire, a ratio of 3:1. Nine patients with intramedullary K-wire required metalwork removal as compared with four in the transcortical group. In the intramedullary group, seven patients with prominent metalwork and two with wound infection required removal of metalwork. In the transcortical group, three patients with prominent metalwork and one due to metalwork failure had their metalwork removed. Nineteen percent of the patients treated with intramedullary K-wires required removal of metalwork as

Fig. 3 – Mayo classification for olecranon fractures. Adapted from Ref. 4. Chalidis et al Journal of Orthopaedic Surgery and Research 2008 3:9.

compared with 25% in patients treated with transcortical K-wires due to prominent metalwork, wound problem and infection (Figs. 6 and 7).

Wound infection developed in two patients (3%). In both cases, oral and intravenous antibiotics proved inadequate for the eradication of the infection. Both cases required surgical debridement and prolonged intravenous antibiotics to eliminate bone infection. Both the patients subsequently had metalwork removal once the fracture healed. Reduction was maintained in all elbows until fracture union except one that had metalwork failure, requiring conversion to open reduction and internal fixation with locking plate. No malunions or non-unions in the rest of the case. There was no ulnar nerve palsies complicating the postoperative period.

Hardware removal was recorded in 13 patients (20%), nine (14%) in the intramedullary configuration as compared with 4

(6%) in the transcortical group (Figs. 6 and 7). Metalworks were removed in all these patients due to pin prominence, infection, localised pain or direct complaint defined as the patient being “bothered” by the metalwork (VAS 1–4). The above event was not significantly affected by pin position as it was found with a frequency of 19% (30 fractures) in the intramedullary group as compared with 25% in the transcortical group. It is noteworthy that after metalwork removal, 10 out of 17 patients (59%) were still complaining for mild discomfort or pain (VAS 1–2).

Using the Chi squared test with Yates' correction for statistical study, we found that there's no significant statistical difference between transcortical and intramedullary K-wire placement with regards to complication rates following tension band wiring of an isolated olecranon fracture requiring removal of metal ($p = 0.89$).

Fig. 4 – Gender distribution in tension band wiring.

5. Discussion

Olecranon fractures may be caused by direct injury to the posterior part of the elbow joint or indirectly by forces generated within the triceps muscle during a fall on a partially flexed elbow.¹⁵ The clinical picture is obvious and conventional radiographs are usually sufficient to depict the lesion and the potential associated injuries.⁴

In our study, the incidence of olecranon fractures showed a higher prevalence among men until the 5th decade of life and among women in older ages. Similarly, Rommens et al⁹ reported that nearly half of men with olecranon fractures were between 21 and 40 years of age and 40% of women between 61 and 80 years of age. Regarding the side of injury, 52.3% of fractures in our series were located in the left limb while Akman et al¹⁶ observed a predominance of right elbow in 60% of cases.

Tension band wiring (TBW) technique, which relies on the principle of converting posterior tensile forces to articular compressive forces, has gained widespread acceptance for the surgical treatment of olecranon fractures.^{17–19} Many authors have suggested various modifications in order to improve the biomechanical properties of the technique.²⁰ Rowland and Burkhart²¹ gave an emphasis on the mathematical need to put the transverse hole for the figure-of-eight tension band wire anterior to the intramedullary pin. The above hypothesis wasn't confirmed by Paremain et al²² as the results of their biomechanical study indicated no significant differences in yield loads or stiffness values between the Rowland–Murkhart and AO tension band wiring techniques.

In spite of the efficacy of TBW fixation even in cases with severe fracture displacement and comminution, many patients express pain or discomfort due to subcutaneous position of the K-wires and the relevant incidence of metalwork

Fig. 5 – Age distribution.

Fig. 6 – Complications in intramedullary configuration group.

removal may be raised to 87%.^{8–10} Rommens et al stated that suboptimal pins placement and K-wires which do not transverse the opposite cortex of the proximal ulna doesn't correlate with the increased rate of implant loosening.⁹ Our study showed there was no significant statistical difference between transcortical and intramedullary K-wire placement with regards to complication rates following tension band wiring of an isolated olecranon fracture requiring removal of metal (Chi squared test with Yates' correction $p = 0.89$).

As the above finding was evident in our study, we advocate that insertion of K-wires into the anterior ulnar cortex may increase TBW construct stability and stiffness but it couldn't prevent posterior pin migration when active motion of the elbow joint has been commenced. Furthermore, hardware removal seems not always to be a panacea for symptoms resolution as 59% of TBW removals in our series were still complaining for mild pain or discomfort. Romero et al¹³ noted that backing-out of K-wires and metalwork prominence could not justify alone the need for TBW removal and they should

Fig. 7 – Complications in the transcortical configuration group.

not be considered entirely responsible for patients' subjective complaints.

Some authors have recommended plating osteosynthesis for fracture stabilization to avoid hardware problems with TBW technique.^{23,24} Bailey et al² reported high patient satisfaction (9.7/10) with a low pain rating (1/10) after plate fixation in Mayo types II and III fractures. Although plate removal was performed in 20% of cases the mean DASH score was consistent with almost normal upper extremity function. Hume and Wiss,²⁵ in a prospective randomised study, found that the application of plates and screws in comparison with TBW construct demonstrated less frequent loss of reduction and better clinical and radiographic results.

Various degrees of postoperative elbow stiffness and deficit of range of motion have been reported in literature after surgical treatment of olecranon fractures.^{1,26,27} Ring et al²⁸ and Teasdall et al²⁹ reported that patient compliance, fracture comminution and extension into the ulnar diaphysis or coronoid process, concomitant radial head fracture and elbow instability may lead to inferior results. On the other hand, Villanueva et al¹⁰ noted that fracture comminution does not necessarily have a harmful effect on both clinical and radiological outcome.

Degenerative changes are not uncommon after olecranon fractures and they have been related to the length of follow-up.¹⁰ Karlsson et al⁸ found that with a mean of 19 years after isolated olecranon fractures 50% of the patients developed degenerative changes. However, these patients did not report any substantial symptoms and no correlation could be found between radiographic findings and patient subjective outcome. The main point is that the functional scores of patients with degenerative changes weren't different of those with normal X-rays. We appreciate that our case series didn't look into this aspect specifically due to the length of follow-up. We also recognise its limitation in interpreting the function and pain after removal of hardware. As such, proper studies and further investigation are required to address the clinical importance of the above issue.

Non-union, ulnar nerve palsy and wound infections have been described in approximately 2–10% of olecranon fractures.^{4,27} Even though the subcutaneous position of the K-wires and their subsequent migration may be responsible for secondary displacement and wound healing problems, careful operative technique and appropriate soft tissue management are of greatest importance in order to minimize the aforementioned complications.

Our results showed that either technique is an acceptable treatment in TBW for isolated olecranon fracture. However, the decision for K-wire placement lies with the experience and familiarity of TBW techniques of the operating surgeon. TBW for olecranon fractures is a common operation performed in any trauma unit. The results of our study showed that both techniques for K-wire placement in TBW are acceptable and do not increase the rate of hardware removal.

We recognise the limitation of this study as this is a retrospective case study with small number of patients. The data collected during the period of study was subjective to the patients' recollection of the pain and complications they encountered throughout the whole period of study. As such, we relied on the patients' recollection of their

experience of this treatment method. We didn't manage to include the arc of motion in all the elbows as the data is incomplete and difficult to obtain especially in the older age group.

6. Conclusion

Tension band wiring fixation for isolated olecranon fractures leads to good elbow function and minimal loss of physical capacity. The technique remains the gold standard for the treatment of displaced and minimally comminuted olecranon fractures despite the introduction of new implants designed specifically to address the problems of wound irritation and metalwork removal. In long term, low levels of pain and elbow degenerative changes may be evident but no clear correlation could be established between radiological and clinical result.

Conflicts of interest

The authors declare that there are no competing interests.

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