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The ideal implant for Mayo 2A olecranon fractures? An economic evaluation

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Background: The ideal implant for stable, noncomminuted olecranon fractures is controversial. Tension band wiring (TBW) is associated with lower cost but higher implant removal rates.On the other hand, plate fixation (PF) is purported to be biomechanically superior, with lower failure and implant removal rates, although associated with higher cost. The primary aim of this study is to look at the clinical outcomes for all Mayo 2A olecranon between PF and TBW. The secondary aim is to perform an economic evaluation of PF vs. TBW.
Materials and Methods: This is a retrospective study of all surgically treated Mayo 2A olecranon fractures in a tertiary hospital from 2005-2016. Demographic data, medical history, range of motion, and complications were collected. All inpatient and outpatient costs in a 1-year period postsurgery including the index surgical procedure were collected via the hospital administrative cost database (normalized to 2014).
Results: A total of 147 cases were identified (94 TBW, 53 PF). PF was associated with higher mean age ($P < .01$), higher American Society of Anesthesiologists score ($P < .01$), and higher proportion of hypertensives ($P = .04$). There was no difference in the range of motion achieved at 1 year for both groups. In terms of complications, TBW was associated with more symptomatic hardware (21.6% vs. 13.7%, $P = .24$) and implant failures (16.5% vs. none, $P < .01$), whereas the plate group had a higher wound complication (5.9% vs. none, $P = .02$) and infection rate (9.8% vs. 3.1%, $P = .09$). TBW had a higher implant removal rate of 30.9% compared with 22.7% for PF ($P = .36$). PF had a higher cost at all time points, from the index surgery ($10,313.64 vs. $5896.36, $P < .01$), 1-year cost excluding index surgery ($5069.61 vs. $3850.46, $P = .46$), and outpatient cost ($1667.80 vs. $1613.49, $P = .27$).
Discussion and Conclusion: Based on our study results, we have demonstrated that TBW is the ideal implant for Mayo 2A olecranon fractures from both a clinical and economic standpoint, with comparable clinical results, potentially similar implant removal rates as PF's, and a lower cost over a 1-year period. In choosing the ideal implant, the surgeon must take into account, first, the local TBW and PF removal rate, which can vary significantly because of the patient's profile and beliefs, and second, the PF implant cost.
Level of evidence: Level III; Retrospective Cohort Comparison; Treatment Study

Keywords: Olecranon fracture; stable; Mayo 2A; tension band wiring; plate fixation; cost effectiveness; economic evaluation

Olecranon fractures represent 10% of all upper extremity fractures.[14] It represents a loss of extensor mechanism of the elbow. The majority of olecranon fractures undergo surgical fixation where the primary aim would be anatomic reduction to restore articular congruity,

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restoration of extensor mechanism, and a stable fixation to allow for early range of motion postoperatively. Common techniques include tension band wiring (TBW) and plate fixation (PF) and, less commonly, intramedullary nailing.[17]

Although there is no debate on the use of PF in unstable, comminuted olecranon fractures, controversy exists in the ideal implant for stable, noncomminuted olecranon fractures. Plate fixation has gained popularity in recent years because of its superior biomechanical properties and lower implant removal and failure rates.[2,6,7] However, multiple studies comparing stable, displaced, noncomminuted olecranon fractures (Mayo type 2A) show comparable patient-reported and functional outcomes in olecranon fractures treated with plate and tension band wire fixation.[4,11,13] A Cochrane review done in 2014 concluded that there is insufficient evidence to draw robust conclusions on the relative effects of the surgical interventions and that further research was needed.[8]

This study primarily aims to look at the clinical outcomes for all Mayo 2A olecranon between PF and TBW. The secondary aim is to perform an economic evaluation between PF and TBW. Our hypothesis is that there is no clinical difference between PF and TBW, and the TBW would be the economically superior option for Mayo 2A olecranon fractures.

Materials and methods

This is a retrospective study looking at all olecranon fractures that underwent surgical fixation in a single tertiary-level hospital in Singapore from January 1, 2005, to December 31, 2016. The STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) guidelines were used to ensure comprehensive reporting of this study.[15]

Surgical records from 2005-2016 were reviewed, and the cases were identified based on the inclusion and exclusion criteria. The radiographs and clinical notes were analyzed. The inclusion criteria were surgically treated olecranon fractures in patients 15 years or older who had a Mayo 2A type fracture identified on the preoperative radiograph. The exclusion criteria were patients younger than 15 years, pathologic fractures, or peri-implant fractures.

Variables collected included demographic data, medical history, injury details, surgery details, and clinical outcomes. Clinical outcomes included range of motion, complications, and reoperation rates. Complications that were collected included failure (implant and bony), infection, wound complications, nonunion, malunion, ulnar neuritis, heterotopic ossification, and symptomatic hardware (with or without implant failure). Implant failure was defined as implant migration or breakage with no loss of reduction such as Kirschner (K)-wire backing out in TBW or screw backing out in plate fixation. Bony failure in contrast was defined as a loss of reduction due to the failure of the fixation construct. Fracture union was defined as bridging cortices on at least 3 of the 4 cortices. Heterotopic ossification was defined as the formation of extraskeletal bone in the elbow. Mayo 2A fractures were identified via review of preoperative radiographs by the primary author, a fellowship-trained orthopedic trauma surgeon.

In our hospital, olecranon fractures usually present to the emergency department and are temporarily immobilized before being referred to the fracture clinic within 2-3 days for assessment and surgical counseling. For the surgically managed olecranon fracture, they are generally treated with a single-day admission where the patient stays overnight postsurgery for monitoring and pain control before being discharged the following day. Follow-up appointments with the orthopedic surgeon are done at a monthly interval on average with radiographs to monitor for fracture union and complications. Referrals to the therapist for range of motion exercises are usually made just prior to hospital discharge. The frequency of therapy visits can be variable dependent on the patient's recovery progress. This typical patient journey was used to decide the methodology for cost calculation.

Costs during the patient's initial index hospitalization for the surgery and subsequent inpatient or outpatient costs up to 1 year were collected. Index hospitalization was defined as all cost related to the initial surgical fixation admission. These costs include the implant cost, hospitalization, and any other miscellaneous cost. The presenting emergency department or specialist outpatient clinic visit were not included as they were assumed to be equal in both groups (TBW, PF). Only fracture-related subsequent inpatient or outpatient costs were included; thus, only specialist outpatient visit data to the orthopedic or physical therapy departments were collected. Any repeat surgery related to the index surgery such as wound débridement as a result of wound infection or removal of implant were included as well. A 1-year follow-up was selected because the vast majority of revision surgeries, in particular, removal of implant—a key cost driver—occurred prior to the 1-year mark. Cost data were collected via the hospital administrative and financial database and normalized to 2014. All costs were reported in Singapore dollars. These costs represent the actual patient charges before any third-party subsidies such as government subsidies or insurance coverage were included.

Statistical analysis

For continuous variables, the descriptive statistics were presented in counts, minimum, maximum, mean (standard deviation), and median (interquartile range). As for the binary and ordinal/categorical variables, proportions, and percentage were presented.

Comparisons among the 2 groups for each continuous variable were done using nonparametric Wilcoxon rank-sum test (ie, Mann-Whitney test). Chi-square test was used for comparing proportions among the groups. The range of motion was analyzed in monthly blocks for the first 6 months, and then from 6 months to 1 year as a single block. Treatment group difference was modeled using generalized linear models (gamma, log link). Cost analysis models were adjusted for age, gender, race, financial aid status, and diagnosis status–specific medical conditions (diabetes, hypertension, dyslipidemia, renal failure, osteoporosis, and ischemic heart disease).

The statistical analysis was performed using Stata/SE, release 13 (StataCorp LP, College Station, TX, USA). All statistical tests were 2-sided at the 5% level. Data with missing information were excluded from that analysis.

Table I Patients demographics

Demographics	Plate fixation (n = 53)	Tension band wiring (n = 94)	*P* value
Sex			.409
Male	19 (35.2)	42 (42.0)	
Female	35 (64.8)	58 (58.0)	
Age, mean (SD)	62.6 (20.5)	53.1 (17.7)	**.003**
Medical comorbidities			
Hypertension	21 (38.9)	23 (23.0)	**.037**
Hyperlipidemia	13 (24.1)	21 (21.0)	.661
Diabetes	9 (16.7)	18 (18.0)	.836
Osteoporosis	6 (11.1)	7 (7.0)	.381
Ischemic heart disease	4 (7.4)	4 (4.0)	.363
Renal failure	2 (3.7)	1 (1.0)	.247
American Society of Anesthesiologist (ASA) score			**.006**
1	5 (9.6)	27 (32.5)	
2	39 (75.0)	24 (50.6)	
3	8 (15.4)	14 (16.9)	

SD, standard deviation.
Unless otherwise noted, values are n (%). Bold *P* values indicate significance.

Results

Demographics

A total of 147 Mayo 2A surgically treated olecranon fractures were identified over a 12-year period. There were 94 that were treated with TBW and 53 by PF. The PF group was associated with a higher mean age of 62.6 years compared with 53.1 years for the TBW group ($P > .01$) and a higher American Society of Anesthesiologists (ASA) score ($P = .006$). PF patients had a higher proportion of hypertension at 38.9% compared with TBW with 23.0% ($P = .037$). There were no significant differences between the other medical comorbidities. Table I describes the demographic and comorbidities distribution.

Clinical outcomes

At 1 year, the TBW group achieved a mean extension of 6.7°, mean flexion of 131.3° and arc of motion of 124.6°, whereas the PF group achieved a mean extension of 8.0°, mean flexion of 117.0°, and arc of motion of 122.5°. There was no statistical difference between the eventual range of motion achieved for both groups at 1 year ($P = .61$ for mean extension, $P = .17$ for mean flexion, and $P = .75$ for arc of motion). With regard to fracture union, PF took 4 weeks longer, at a mean of 15 weeks, than TBW to achieve radiographic union, at 11 weeks ($P < .01$).

Complications

Complication rates are illustrated in Table II. TBW was associated with more symptomatic hardware (21.6% vs. 13.7%, $P = .24$) and implant failures (16.5% vs. none, $P < .01$), whereas the plate group had a higher wound complication (5.9% vs. none, $P = .02$) and infection rate (9.8% vs. 3.1%, $P = .09$). TBW was also associated with a higher implant removal rate of 30.9% compared with 22.7% in PF ($P = .36$).

Cost analysis

Cost data are summarized in Table III. The index hospitalization cost $4124.30 more in the PF group compared with the TBW group ($P < .01$). Subsequent cost at 1 year excluding the index hospitalization was higher for the PF group at $5069.61 compared with the TBW group at $3850.46 despite a higher implant removal rate in the TBW group; however, it did not reach statistical significance ($P = .46$). The cost of outpatient treatment was similar in both groups at $1667.80 for PF and $1613.49 for TBW ($P = .27$). Specific implant costs were not able to be generated from the administrative and financial database; however, based on hospital tender contracts for implants, TBW was priced at an average of $40 and the locking PF at $1700.

Discussion

The aim of our study was to investigate the clinical effectiveness and to perform an economic evaluation of PF compared to TBW in this group of fractures. Our study demonstrated similar clinical outcomes between TBW and PF. TBW was associated with higher hardware prominence, implant failure, and implant removal rate. PF was associated with higher wound complication rate, higher infection rate, and slower union time. TBW was shown to be the more economical alternative to PF in the management of Mayo 2A fractures. Most of the cost savings originate from the difference in the initial implant cost for the index

Table II Complications between plate fixation and tension band wiring

Complications	Plate fixation (n = 53)	Tension band wiring (n = 94)	*P* value
Removal	12 (22.7)	29 (30.9)	.364
Symptomatic hardware	7 (13.7)	21 (21.6)	.242
Failure			**.006**
Implant failure	0 (0.0)	16 (16.5)	
Bony failure	1 (2.0)	4 (4.1)	
Wound	3 (5.9)	0 (0.0)	**.016**
Infection	5 (9.8)	3 (3.1)	.086
Ulnar neuritis	1 (2.0)	3 (3.1)	.687
Nonunion	0 (0.0)	2 (2.1)	.302
Heterotopic ossification	0 (0.0)	2 (2.1)	.302

Values are n (%). Bold *P* values indicate significance.

Table III Cost comparison between plate fixation and tension band wiring

Mayo 2A	Unadjusted means (SD)		Adjusted difference	*P* value
	Plate fixation (n = 53)	Tension band wiring (n = 94)		
Cost of index episode, $	10,313.64 (7904.36)	5896.36 (5791.25)	4124.30 (2103.53, 6145.06)	**<.001**
1-year costs (excludes index), $	5069.61 (10, 260.19)	3850.46 (5496.638)	554.51 (−921.50, 2030.53)	.462
Cost of outpatient visits, $	1667.80 (1391.80)	1613.49 (1768.36)	175.52 (−759.76, 208.72)	.265

SD, standard deviation.
Bold *P* value indicates significance.

surgery. Despite the additional cost of the higher rates of removal of implants for the TBW group, the cost of PF was still higher at 1 year.

Duckworth et al's prospective randomized landmark study in 2017[4] comparing TBW and PF for treatment of 67 Mayo 2A olecranon fractures reported that the TBW group had higher rates of symptomatic hardware and implant failure whereas the PF group had higher rates of wound complications and infection. The 2 groups of patients also demonstrated comparable patient-reported outcome measures. These findings were similar in our study. However, the authors concluded that there was no difference in terms of cost. There are several possible reasons for this. First, they reported a higher rate of 50% for implant removal for TBW, and second, a lower standardized locking plate cost of $836.72 was used for their economic analysis.

A smaller retrospective study by Amini et al in 2010[1] comparing TBW and PF for transverse olecranon fractures found that, overall, costs were significantly higher for PF ($14,333.46 vs. $6598.36) despite a higher rate of hardware removal for TBW (40% vs. 10%). Similar to Duckworth et al's study, there was no difference in functional outcomes between PF and TBW. However, previous reviews of the study highlighted the use of a significantly higher implant cost of locked plates of $6688.52, the use of insurance company billing to estimate operative cost (which tends to overestimate the cost), and the small patient number of 20 patients.[5] The authors concluded that even if the implant removal rate was 100% for TBW, TBW would be the most cost-effective strategy.

More recently, Francis et al in 2017[5] published an expected value decision tree that included predicted societal cost using pooled data from literature. Sensitivity analysis and strategy tables using different TBW implant removal rates and implant costs concluded that at a 70% TBW implant removal rate, locked plating became the dominant strategy assuming a baseline 20% removal rate for PF. It is worth pointing out that this study used a range of $200-$2400 for PF implant cost when doing its sensitivity analysis.

Our study affirms current literature, which reports equal functional outcomes between TBW and PF, with TBW having a higher complication rate, in particular, implant removal rates. The main determinants for cost effectiveness stemmed primarily from the implant removal rate and implant cost, which can vary significantly from population to population.

Our study highlights several key points. First, the difference in implant removal rate for TBW and PF was not markedly different in our study (27% for TBW vs. 19% for PF). Our observation is that in a predominately Asian population with less soft tissue coverage over the elbow, the large bulky precontoured locking plates used for fixation can cause significant hardware irritation as well as necessitate an implant removal. In addition, our study showed that a significant number of patients underwent implant removal despite the absence of symptomatic hardware, regardless of implant choice. Our observation is that a perception exists in a predominantly Asian population where metal implants are harmful if left in situ regardless of whether they are symptomatic. Claessen et al[3] investigated reasons for removal of implants in olecranon fractures, and the main reason for elective removal of implants was patient's personal preference. It was also associated with female gender and younger age as opposed to type or configuration of implant. In such a scenario where implant removal rates are similar, there is a very strong case for TBW for Mayo 2A olecranon fractures. From a cost perspective, our study showed that the total cost for PF at 1 year was $15,383.25 compared with $9746.82 for TBW.

In reducing the risk of implant failure in TBW, it is recommended for adequate cortical purchase of the volar cortex of the ulna by the transversing K-wires to prevent backing out. Sinking of the bent proximal end of the K-wire through a small incision in the triceps, into the proximal ulna with subsequent closing of the incision over the K-wires may also reduce rates of implant failure. Irritation of the soft tissue resulting in symptomatic hardware could also be minimized by ensuring that the twisted ends of the cerclage wire is trimmed short, with both ends turned toward the ulna. Schneider et al[12] outlined the common TBW technical errors that, if avoided, may potentially reduce implant failure, hardware irritation, and implant removal rates, thereby further reducing the cost.

Second, proponents for PF in olecranon fractures often quote several reasons for its use such as its biomechanical superiority and thus a lower failure rate.[2,6] Some authors have suggested abandoning TBW altogether because of a potential concern for underdiagnosed articular comminution on radiographs, which can only be picked up on a computed tomographic scan.[16] Although PF is clearly indicated for unstable olecranon fractures (Mayo 2B and 3), when looking at Mayo 2A fractures, our study did not show any difference in bony failures between TBW and PF. Of particular note, PF was associated with higher wound complications, infection, and slower union rates compared with TBW.

One of the significant strengths of our article is the size of the study population. To our knowledge, this is the largest comparison of TBW and PF of Mayo 2A olecranon fractures in literature. The 2 other cohort studies to date that studied Mayo 2A fractures were Tarallo et al in 2014[13] (n = 31) and Schliemann et al in 2014[11] (n = 26). Both reported similar functional outcome scores and a higher implant removal rate with TBW vs. PF (38% vs. 17%) and (92% vs. 54%), respectively. A systematic review and meta-analysis by Ren et al in 2017[10] was not able to identify further studies and pooled together the data from these 2 studies.

Second, the economic evaluation used by the previous studies may not be fully representative of the true cost associated with the treatment of these fractures. In Duckworth et al, the authors used a standardized cost and not the actual cost with regard to hospitalization days, cost of treatment, clinic appointments, and complications to calculate cost effectiveness. In Amini et al's study, only surgery-related costs were included and outpatient costs were excluded. The Francis et al study was based on cost modeling with assumptions. Our study attempted to be as comprehensive as possible in collecting actual cost data both in an inpatient and an outpatient setting. However, given the retrospective data, productivity loss and other societal costs could not be obtained.

There are several limitations of our study. First, patient-reported functional outcome measures were not collected because of the retrospective nature of this study. Our study focused on range of motion as a surrogate measure of functional outcome, which was not shown to be significantly different between the TBW and PF groups. Value in health care is defined as patient outcomes divided by cost.[9] This incomplete nature of outcome assessment affects the ability to draw a more definitive conclusion on the ideal or "value"-based implant for Mayo 2A olecranon fractures.

Second, cost data were only collected till 1 year following the index procedure. In the event that further procedures were performed after 1 year, those costs were not included. Complications such as infections and implant prominence necessitating its removal would generally present itself within 1 year, and the vast majority of our patients were discharged within 1 year of their index surgery.

Conclusion

Based on our study results, we have demonstrated that TBW is the ideal implant for Mayo 2A olecranon fractures from both a clinical and economic standpoint, with comparable clinical results, potentially similar implant removal rates as PF's, and a lower cost over a 1-year period. However, it must be emphasized that an individualized approach must be taken for every patient. Patient engagement is key in this respect. In choosing the ideal implant for every individual patient, the surgeon should assess each patient's profile, discuss the local TBW and PF removal rates, the local PF implant cost, and explore with each patient his or her individual preferences and beliefs.

Disclaimer

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References

1. Amini MH, Azar FM, Wilson BR, Smith RA, Mauck BM, Throckmorton TW. Comparison of outcomes and costs of tension-band and locking-plate osteosynthesis in transverse olecranon fractures: a matched-cohort study. Am J Orthop (Belle Mead, NJ) 2015;44:E211-5.
2. Buijze G, Kloen P. Clinical evaluation of locking compression plate fixation for comminuted olecranon fractures. J Bone Joint Surg Am 2009;91:2416-20. https://doi.org/10.2106/jbjs.H.01419
3. Claessen FM, Braun Y, Peters RM, Dyer G, Doornberg JN, Ring D. Factors associated with reoperation after fixation of displaced olecranon fractures. Clin Orthop Relat Res 2016;474:193-200. https://doi.org/10.1007/s11999-015-4488-2
4. Duckworth AD, Clement ND, White TO, Court-Brown CM, McQueen MM. Plate versus tension-band wire fixation for olecranon fractures: a prospective randomized trial. J Bone Joint Surg Am 2017; 99:1261-73. https://doi.org/10.2106/jbjs.16.00773
5. Francis T, Washington T, Srivastava K, Moutzouros V, Makhni EC, Hakeos W. Societal costs in displaced transverse olecranon fractures: using decision analysis tools to find the most cost-effective strategy between tension band wiring and locked plating. J Shoulder Elbow Surg 2017;26:1995-2003. https://doi.org/10.1016/j.jse.2017.07.017
6. Hak DJ, Golladay GJ. Olecranon fractures: treatment options. J Am Acad Orthop Surg 2000;8:266-75.
7. Macko D, Szabo RM. Complications of tension-band wiring of olecranon fractures. J Bone Joint Surg Am 1985;67:1396-401.
8. Matar HE, Ali AA, Buckley S, Garlick NI, Atkinson HD. Surgical interventions for treating fractures of the olecranon in adults. Cochrane Database Syst Rev 2014;2014:CD010144. https://doi.org/10.1002/14651858.CD010144.pub2
9. Porter ME, Teisberg EO. How physicians can change the future of health care. JAMA 2007;297:1103-11. https://doi.org/10.1001/jama.297.10.1103
10. Ren YM, Qiao HY, Wei ZJ, Lin W, Fan BY, Liu J, et al. Efficacy and safety of tension band wiring versus plate fixation in olecranon fractures: a systematic review and meta-analysis. J Orthop Surg Res 2016; 11:137. https://doi.org/10.1186/s13018-016-0465-z
11. Schliemann B, Raschke MJ, Groene P, Weimann A, Wahnert D, Lenschow S, et al. Comparison of tension band wiring and precontoured locking compression plate fixation in Mayo type IIA olecranon fractures. Acta Orthop Belg 2014;80:106-11.
12. Schneider MM, Nowak TE, Bastian L, Katthagen JC, Isenberg J, Rommens PM, et al. Tension band wiring in olecranon fractures: the myth of technical simplicity and osteosynthetical perfection. Int Orthop 2014;38:847-55. https://doi.org/10.1007/s00264-013-2208-7
13. Tarallo L, Mugnai R, Adani R, Capra F, Zambianchi F, Catani F. Simple and comminuted displaced olecranon fractures: a clinical comparison between tension band wiring and plate fixation techniques. Arch Orthop Trauma Surg 2014;134:1107-14. https://doi.org/10.1007/s00402-014-2021-9
14. Veillette CJ, Steinmann SP. Olecranon fractures. Orthop Clin North Am 2008;39:229-36.vii. https://doi.org/10.1016/j.ocl.2008.01.002
15. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. J Clin Epidemiol 2008;61:344-9. https://doi.org/10.1016/j.jclinepi.2007.11.008
16. Wellman DS, Lazaro LE, Cymerman RM, Axelrad TW, Leu D, Helfet DL, et al. Treatment of olecranon fractures with 2.4- and 2.7-mm plating techniques. J Orthop Trauma 2015;29:36-43. https://doi.org/10.1097/BOT.0000000000000152
17. Wiegand L, Bernstein J, Ahn J. Fractures in brief: olecranon fractures. Clin Orthop Relat Res 2012;470:3637-41. https://doi.org/10.1007/s11999-012-2393-5