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Correlation between modified trochleocapitellar index and post-traumatic elbow stiffness in type C2-3 distal humeral fractures among adults

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Background: The purpose of this study was to propose the modified trochleocapitellar index (mTCI), assess its reliability, and evaluate its correlation with post-traumatic elbow stiffness in type C2-3 distal humeral fractures among adults.

Methods: From January 2013 to June 2017, a total of 141 patients with type C2-3 distal humeral fractures were included. The mTCI was calculated as the ratio between the modified trochlear and capitellar angles relative to the humeral axis (mTCI-HA), lateral humeral line (mTCI-LHL), and medial humeral line (mTCI-MHL) from anteroposterior radiographs taken immediately after the operation. The patients were divided into group A (with elbow stiffness) and group B (without elbow stiffness) based on follow-up results. To determine risk factors for elbow stiffness, univariate and logistic regression analyses were performed on each radiographic parameter separately, together with other clinical variables. Interrater reliability was assessed for all measurements.

Results: Specific optimal ranges of value were identified for mTCI-HA (0.750-0.875), mTCI-LHL (0.640-1.060), and mTCI-MHL (0.740-0.900), beyond which the likelihood of elbow stiffness significantly increased ($P < .001$). By multivariate analysis, mTCI-HA (odds ratio [OR] 26.22, 95% confidence interval [CI] 3.39-203.07, $P = .002$), mTCI-LHL (OR 5.37, 95% CI 2.17-13.28, $P < .001$), and mTCI-MHL (OR 5.95, 95% CI 1.91-18.56, $P = .002$) values beyond the optimal ranges were identified as the independent risk factors for elbow stiffness. The interrater reliability of mTCI-HA, mTCI-LHL, and mTCI-MHL was 0.986, 0.983, and 0.987, respectively.

Conclusion: The mTCI measurement method is reliable. Either too small or too large mTCI values were associated with post-traumatic elbow stiffness among adult patients with type C2-3 distal humeral fractures. The mTCI-HA showed a better predictive value than mTCI-LHL and mTCI-MHL.

Level of evidence: Basic Science Study; Development of Classification System

Keywords: Distal humeral fractures; modified trochleocapitellar index; elbow stiffness; risk factor; logistic regression analysis; open reduction and internal fixation

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Distal humeral fractures are relatively uncommon among adults, fractures and account for only 2% of all fractures, with an overall incidence of 5.7 per 100,000 persons per year.[21,22] Intercondylar fractures of the distal

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humerus, classified as type 13C based on the Orthopaedic Trauma Association (OTA) classification system,[20] represent the most complex intra-articular fractures that are often associated with poor postoperative elbow function and have high rates of complications such as elbow stiffness, nonunion, and infection.[2,17,22,24,26] Achieving satisfactory clinical outcomes and avoiding secondary issues relies on anatomic reduction of the articular surface, together with stable osteosynthesis and appropriate rehabilitation.[6,8,15,25] However, achieving these goals remains challenging in some cases, and elbow stiffness is still one of the most common postoperative complications. Having a stiff elbow—a common complication among patients with type C2-3 distal humeral fractures—significantly impairs the activities of daily living for many patients.[1,9,26]

Postoperative radiographs allow for evaluation for reduction of the articular surface.[21] The trochleocapitellar index (TCI), which was first introduced by Gorelick et al,[11] was applied to assess the adequacy of reduction and angulation deformity based on the anteroposterior (AP) view of X-ray films among children with supracondylar fractures of the distal humerus. Rollo et al[23] applied this idea to adults to assess the anatomic reduction in type C1 distal humeral fractures and found moderate predictive values of TCI for the functional results. However, because the contour of the capitellum in adults resembles a semicircle, unlike the relatively flat surface of the growth plate in children, drawing the "distal line of capitellum" or the "distal line of trochlea" as described in their article could be a hard task.

In this study, we developed a measurement protocol based on the TCI method and proposed it as the modified trochleocapitellar index (mTCI). Here, we aimed to assess its reliability and evaluate the clinical relevance between mTCI and post-traumatic elbow stiffness among adults with comminuted intercondylar fractures of the distal humerus (type C2-3) treated by open reduction and internal fixation (ORIF) using double-plate osteosynthesis.

Materials and methods

Patients with intercondylar fractures of the distal humerus who received surgical treatment in our hospital from January 2013 to June 2017 were included, and the patient information was extracted from our database. A retrospective study was conducted with the following inclusion criteria: (1) Arbeitsgemeinschaft für Osteosynthesefragen (AO)/Orthopaedic Trauma Association classification of 13C2 and C3; (2) treated by ORIF using double-plate osteosynthesis (orthogonal or parallel configuration); (3) complete perioperative and postoperative follow-up data; and (4) minimum follow-up period of 1 year. The exclusion criteria were as follows: (1) pathologic fractures, (2) unclosed epiphysis, (3) ipsilateral fractures of radius, (4) lost to follow-up, and (5) age <18 years. A total of 141 patients met our criteria and were enrolled in the study, including 72 men and 69 women. The mean age of all patients was 43 ± 16 years (range, 18-79).

The enrolled patients all underwent ORIF using locking compression plates based on a bicolumnar plating system (orthogonal or parallel) through either olecranon osteotomy or a triceps-sparing approach according to the fracture type and surgeon's experience. Tension band fixation was adopted if olecranon osteotomy was performed. The ulnar nerves were either transposed subcutaneously or decompressed in situ according to the preoperative symptoms, intraoperative findings, and clinical experience of the surgeons. The patients were asked to start passive range of motion (ROM) exercise in the first 4 weeks. Then they were instructed to perform active ROM exercise in the fifth to eighth week. The patients would perform all aforementioned exercises 4 times per day and 1 hour continuously for each time. After 8 weeks, they were allowed to exercise against resistance. Eventually, after the fracture was healed, they were told to exercise normally.

The patients were divided into 2 groups according to the latest follow-up results. Group A (elbow stiffness) had a <100° ROM in flexion-extension and/or pronation-supination and/or underwent elbow arthrolysis. Group B (without elbow stiffness) had a ROM of both flexion-extension and pronation-supination greater than 100° without a history of elbow release surgery.

From the standard AP view of radiographs taken immediately after the surgery, the radiographic parameters (mTCI) were measured using the following protocol (see Fig. 1). The mTCIs consists of the mTCI-HA (humeral axis), mTCI-LHL (lateral humeral line), and mTCI-MHL (medial humeral line), which were defined as the modified trochlear angle divided by the modified capitellar angle. The humeral axis (axis of the humeral shaft), LHL, and MHL (drawn along the lateral and medial side of the humeral shaft cortex, respectively) are the measuring axes. The modified trochlear angle is defined as the angle between the measuring axis and the line that passes through the lateral and medial ridge of the trochlea (trochlear line: reflects the extent of the reduction of the medial column). The modified capitellar angle is defined as the angle between the measuring axis and the line that passes through the endpoints of the lateral and medial edge of the articular surface of the radial head (indirect capitellar line: indicates the alignment of the capitellum if the satisfactory anatomic reconstruction of the lateral column has been achieved). Therefore, the values of mTCIs reflect the adequacy of articular reduction of only the medial column. All measurements were calculated and recorded. Interrater reliability was examined by 2 different authors (first author and second author) using the above methods to measure the mTCI-HA, mTCI-LHL, and mTCI-MHL.

Previous studies showed that either too large or too small a value of the TCI indicates malreduction of the distal humerus.[23] Therefore, by computer programming using Python (3.7.4 for Windows), we traversed and iterated all possible combinations of the upper and lower limits to find the optimal ranges of mTCI-HA, mTCI-LHL, and mTCI-MHL; thus, values beyond these ranges can best predict post-traumatic elbow stiffness. Based on the principle of diagnostic test, the most optimal range was defined as having the maximum Youden index. If multiple combinations had the same maximum Youden index, the combination with the highest sensitivity was defined as the optimal range.

Univariate analysis was conducted with mTCI-HA, mTCI-LHL, and mTCI-MHL based on the identified ranges, respectively. Other factors were also statistically analyzed and compared between the 2 groups, including age, sex, fracture side, mechanism of injury, AO classification, fracture type (open or closed), existence of additional fractures, time from injury to surgery, surgical approach, operation time, configuration of fixation, and use of anti–heterotopic ossification (HO) drugs (glucosamine indomethacin enteric-coated tablets).

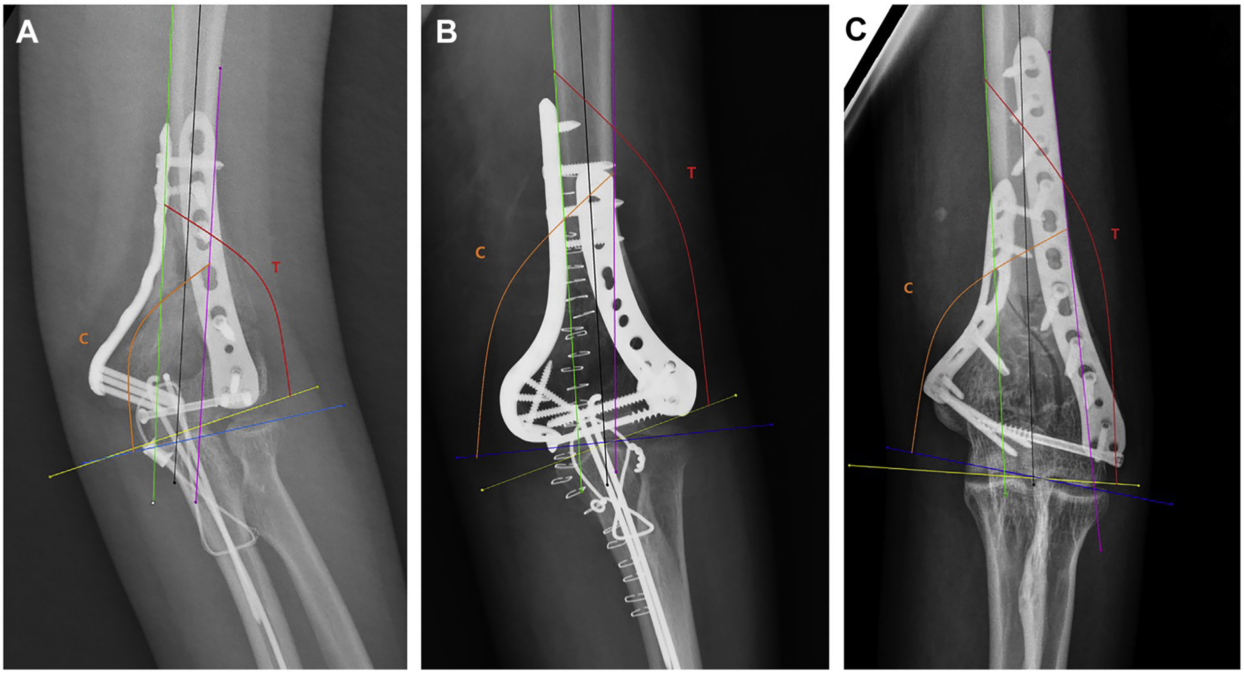

Figure 1 The measuring protocols of modified trochleocapitellar index (mTCI) were demonstrated from the anteroposterior view of radiographs taken immediately after the operation showing different values of mTCI: (**A**) too small, (**B**) normal, or (**C**) too large. Line A (*yellow line*) is the trochlear line, which passes through the lateral and medial ridge of the trochlea. Line B (*blue line*) is the indirect capitellar line, which passes through the endpoint of the lateral and medial edge of the articular surface of the radial head. The intersection angles of line A with the humeral axis (HA, *black line*), lateral humeral line (LHL, *purple line*), and medial humeral line (MHL, *green line*) were calculated as T-HA, T-LHL, and T-MHL, respectively (*red arc*). The intersection angles of line B with the HA (*black*), LHL (*purple*), and MHL (*green*) were calculated as C-HA, C-LHL, and C-MHL, respectively (*orange arc*). Then, T-HA, T-LHL, and T-MHL were divided by C-HA, C-LHL, and C-MHL, resulting in the ratios of mTCI-HA, mTCI-LHL, and mTCI-MHL, respectively.

Logistic regression analyses were performed on mTCI-HA, mTCI-LHL, and mTCI-MHL separately, and each model contained the clinical variables that were significant ($P < .10$) in univariate analyses.

Statistical analysis

IBM SPSS 23.0 for Windows (IBM, Armonk, NY, USA) was used to perform all statistical analyses. Categorical variables were described as n (%) and compared by χ^2 tests or Fisher exact tests as appropriate. Continuous variables were described as the mean ± standard deviation or median (25th percentile, 75th percentile) and compared by the *t* test or Mann-Whitney *U* test (if it did not follow normal distribution), respectively. Variables yielding *P* values <.10 by univariate analysis were further assessed using logistic regression models to determine the independent risk factors. The level of significance was set as $P < .05$. The intraclass correlation coefficient (ICC) was used to determine the interrater reliability of all variables. The ICC values ranged from 0 to 1, and values above 0.75 were considered to indicate excellent reliability.

Results

The average follow-up period was 31.9 ± 14.3 months (range, 12-63). Group A (with elbow stiffness) consisted of 35 patients (24.8%), whereas group B (without elbow stiffness) consisted of 106 patients (75.2%). All patients of group A had limited extension-flexion ROM without rotational function impairment. All postoperative radiographs in both groups demonstrated bone union at the latest follow-up. No incidents of wound dehiscence, superficial or deep infection, hardware failure, or loosening occurred. In total, 16 patients underwent open arthrolysis for elbow stiffness.

The mean value of mTCI-HA, mTCI-LHL, and mTCI-MHL were 0.917 ± 0.191 (range, 0.487-1.563), 0.954 ± 0.225 (range, 0.526-1.628), and 0.928 ± 0.194 (range, 0.486-1.587), respectively. The interrater reliability of mTCI-HA, mTCI-LHL, and mTCI-MHL were 0.986, 0.983, and 0.987, respectively.

The optimal ranges (lower limits–upper limits) were identified for mTCI-HA (0.750-0.875), mTCI-LHL (0.640-1.060), and mTCI-MHL (0.740-0.900) beyond which the patients were more likely to develop post-traumatic elbow stiffness comparing to those within ($P < .001$) (Table I). The Youden indexes of 3 parameters are shown in Table I.

The patient characteristics are presented in Table II. Univariate analyses showed that high-energy injury mechanism ($P = .007$), time from injury to surgery >1 week ($P = .001$), operation time >150 minutes ($P = .016$),

Table I Efficacy of the optimal ranges in mTCI-HA, mTCI-LHL, and mTCI-MHL for predicting post-traumatic elbow stiffness

Measurement ranges	Group A: Elbow stiffness, % (n = 35)	Group B: No elbow stiffness, % (n = 106)	*P* value	Youden index
mTCI-HA			<.001	0.396
<0.750 or ≥0.875	34 (96.9)	61 (57.5)		
≥0.750 and <0.875	1 (3.1)	45 (42.5)		
mTCI-LHL			<.001	0.392
<0.640 or ≥1.060	20 (57.1)	19 (17.9)		
≥0.640 and <1.060	15 (42.9)	87 (82.1)		
mTCI-MHL			<.001	0.386
<0.744 or ≥0.910	31 (88.6)	53 (50.0)		
≥0.744 and <0.910	4 (11.4)	53 (50.0)		

mTCI, modified trochleocapitellar index; *HA*, humeral axis; *LHL*, lateral humeral line; *MHL*, medial humeral line.

and no anti-HO drug administration ($P = .05$) were statistically significant factors for post-traumatic elbow stiffness. The other variables, including age, sex, fracture side, AO classification, fracture type (open or closed), existence of additional fractures, surgical approach, and configuration of fixation, were confounding factors without statistical significance (Table II).

Logistic regression analyses showed that mTCI-HA (odds ratio [OR] 26.22, 95% confidence interval [CI] 3.39-203.07, $P = .002$), mTCI-LHL (OR 5.37, 95% CI 2.17-13.28, $P < .001$), and mTCI-MHL (OR 6.72, 95% CI 2.16-20.90, $P = .001$) were all independent risk factors for elbow stiffness in each statistical model, respectively. In addition, high-energy injury mechanism and time from injury to surgery >1 week were significantly associated with post-traumatic elbow stiffness in all 3 logistic regression models ($P < .05$). However, the operation time and anti-HO drug administration did not have significant associations with post-traumatic elbow stiffness ($P > .05$) (Tables III-V).

Discussion

Type C2-3 distal humeral fracture is one of the most severe and complex comminuted intra-articular fractures and poses great challenge for orthopedic surgeons.[2,21] Patients with this type of fracture are prone to developing post-traumatic elbow stiffness with an OR of 16.6 compared with that of patients with other subtypes of distal humeral fractures.[26] Thus, as shown in our study, the incidence of post-traumatic elbow stiffness (24.8%, 35/141) was relatively higher than previous studies.[10,16,21,22,24]

The TCI is a new method for assessing the reduction of distal humeral fractures.[23] Originally proposed by pediatric orthopedic surgeons, the TCI was applied to identify abnormal alignment of the elbow to avoid unnecessary bilateral comparative films.[11] Additionally, TCI was expected to be more accurate and comprehensive in determining the adequacy of reduction because it significantly decreases potential rotational errors, which tend to occur in unilateral radiographic measurements such as the Baumann angle.[12]

For intercondylar fractures of the distal humerus among adults, achieving anatomic reduction is imperative to slow down the progression of post-traumatic osteoarthritis.[4] Thus, Rollo et al[23] adopted this measurement technique in adults to evaluate the balance between the reduction of the medial and lateral columns in type C1 distal humeral fractures. However, the shape of the adult capitellum and trochlea is relatively complex and irregular compared to the flat and smooth growth plate of children; therefore, drawing the "distal line of capitellum" or the "distal line of trochlea," described in Rollo's work that resembles the method of pediatric orthopedics, could be difficult and might produce inconsistent results when measured by different surgeons.

Therefore, we modified the TCI measurements by replacing the "trochlear line" with the line through the lateral and medial ridge of the trochlea as well as the "capitellar line" with another line through the endpoints of the lateral and medial edge of the articular surface of the radial head and define them as the trochlear line and the indirect capitellar line, respectively. Although mTCI-HA, mTCI-LHL, and mTCI-MHL can only demonstrate the adequacy of articular reduction of the medial column, we adopted the linear axiom of "2 points determine a line" by connecting the 4 aforementioned radiographic anatomic landmarks (trochlea ridges and radial head edges), which can be easily and clearly identified on AP views of radiographs and drawn with high accuracy and reproducibility. As shown in our study, the measurements of all parameters including mTCI-HA (ICC = 0.986), mTCI-LHL (ICC = 0.983), and mTCI-MHL (ICC = 0.987) were reliable and reproducible with excellent interrater reliability. It is worth noting that all patients in our study with elbow stiffness had only compromised ROM in extension-flexion, which mostly depends on the articulation of the ulnohumeral joints; thus, evaluating the adequacy of the reduction of the

Table II Univariable analysis of clinical variables

Clinical variables	Group A: Elbow stiffness, % (n = 35)	Group B: No elbow stiffness, % (n = 106)	*P* value
Age, yr, mean ± SD (range)	40.69 ± 15.76 (14-71)	44.00 ± 15.94 (14-79)	.287
Sex			.960
Male	18 (51.4)	54 (50.9)	
Female	17 (48.6)	52 (49.1)	
Fracture side			.811
Dominant side	14 (40.0)	40 (37.7)	
Nondominant side	21 (60.0)	66 (62.3)	
Injury mechanism			.007
High-energy	19 (54.3)	31 (29.2)	
Low-energy	16 (45.7)	75 (70.8)	
AO classification			.528
C2	17 (48.6)	58 (54.7)	
C3	18 (51.4)	48 (45.3)	
Fracture type			.924
Open fracture	7 (20.0)	22 (20.8)	
Closed fracture	28 (80.0)	84 (79.2)	
Additional fractures			.125
Yes	5 (14.3)	5 (4.7)	
No	30 (85.7)	101 (95.3)	
Time from injury to surgery			.001
≤7 d	18 (51.4)	84 (79.2)	
>7 d	17 (48.6)	22 (20.8)	
Operation time			.016
≤150 min	14 (40.0)	67 (63.2)	
>150 min	21 (60.0)	39 (36.8)	
Approach			.849
OO	26 (74.3)	77 (72.6)	
TS	9 (25.7)	29 (27.4)	
Configuration of fixation			.456
Orthogonal	34 (97.1)	97 (91.5)	
Parallel	1 (2.9)	9 (8.5)	
Anti-HO drugs			.050
Yes	2 (5.7)	21 (19.8)	
No	33 (94.3)	85 (80.2)	

AO, Arbeitsgemeinschaft für Osteosynthesefragen; *OO*, olecranon osteotomy; *TS*, triceps sparing; *HO*, heterotopic ossification.

medial column using mTCI is reasonable, particularly important and necessary.

In our study, we found a distinct correlation between mTCI and post-traumatic elbow stiffness. Patients with values of mTCI-HA, mTCI-LHL, and mTCI-MHL beyond certain ranges significantly increased the likelihood of developing limited ROM. Therefore, either too small or too large values of the modified ratios, which indicate malreduction of the medial column and mild incongruence of ulnohumeral articulation, may serve as the harbinger of

Table III Risk factors for post-traumatic elbow stiffness (logistic regression analysis for mTCI-HA)

Risk factors	Odds ratio (95% CI)	*P* value
mTCI-HA (<0.750 or ≥0.875)	26.22 (3.39-203.07)	.002*
High-energy injury mechanism	3.234 (1.31-8.00)	.011*
Time from injury to surgery >1 week	3.83 (1.50-9.82)	.005*
Operation time >150 min	1.87 (0.75-4.65)	.178
No anti-HO drugs administration	2.89 (0.57-14.74)	.202

mTCI, modified trochleocapitellar index; *HA*, humeral axis; *HO*, heterotopic ossification; *CI,* confidence interval.
* Statistically significant ($P < .05$).

Table IV Risk factors for post-traumatic elbow stiffness (logistic regression analysis for mTCI-LHL)

Risk factors	Odds ratio (95% CI)	*P* value
mTCI-LHL (<0.640 or ≥1.060)	5.37 (2.17-13.28)	<.001*
High-energy injury mechanism	3.00 (1.22-7.38)	.017*
Time from injury to sugery >1 week	3.36 (1.31-8.59)	.012*
Operation time >150 min	1.67 (0.68-4.01)	.270
No anti-HO drugs administration	3.40 (0.70-16.56)	.130

mTCI, modified trochleocapitellar index; *LHL*, lateral humeral line; *HO*, heterotopic ossification; CI, confidence interval.
* Statistically significant ($P < .05$).

Table V Risk factors for post-traumatic elbow stiffness (logistic regression analysis for mTCI-MHL)

Risk factors	Odds ratio (95% CI)	*P* value
mTCI-MHL (<0.740 or ≥0.900)	6.72 (2.16-20.90)	.001*
High-energy injury mechanism	2.78 (1.16-6.65)	.022*
Time from injury to surgery >1 week	3.41 (1.38-8.40)	.008*
Operation time >150 min	2.06 (0.86-4.95)	.106
No anti-HO drugs administration	2.63 (0.54-12.76)	.231

mTCI, modified trochleocapitellar index; *MHL*, medial humeral line; *HO*, heterotopic ossification; CI, confidence interval.
* Statistically significant ($P < .05$).

elbow stiffness. We assumed that the malreduction of the medial column may cause overlapping of the bony structures at the olecranon and coronoid fossa or formation of osteophytes around the articular surface, which will cause mechanical blockage or stimulate contracture or calcification of the ligaments and joint capsules that adversely affects the arc of motion. Studies to validate these correlations and the underlying mechanism are required.[3,18]

Additionally, we aimed to further compare the predictive value of the mTCIs using different measurement axes (humeral axis, lateral humeral line, and medial humeral line[16]) to determine the modified trochlear and capitellar angles and find a suitable parameter. We found a similar Youden index for mTCI-HA (0.396), mTCI-LHL (0.392), and mTCI-MHL (0.386). However, the OR for mTCI-HA (OR 26.22, 95% CI 3.39-203.07, $P = .002$) was significantly higher than that of the other 2 measurements. Therefore, we believe that mTCI-HA yields better predictive value for post-traumatic elbow stiffness in type C2-3 distal humeral fractures after ORIF than the other 2 measurements.

In clinical practice, patients with either too large or too small mTCI values should be informed and warned about the possibility of elbow stiffness, and surgeons should properly lower the patients' overly optimistic expectations about a perfect functional recovery. Most importantly, patients should be instructed to strictly follow the appropriate and disciplinary rehabilitation protocols.[10] If possible, patients should be referred to a specialized rehabilitation department for customized recovery training exercises. Additionally, to optimize clinical outcomes, surgeons and physicians may use more enabling and empowering language and apply more intensive coaching, or even cognitive therapies and social support to improve patients' self-efficacy and coping abilities toward rehabilitations.[14] For patients with high risks of developing post-traumatic elbow stiffness, indomethacin or other anti-HO drugs can be administered orally in a low-dose and short-term manner, which have been proven safe from bone-healing complications in previous studies.[5,19,27] In addition, we recommend routinely taking standard high-resolution AP radiographs of the injured elbow covering as much of the humeral shaft as possible using a C-arm or G-arm after internal fixation and before wound closure. If the images reveal either too small or too large mTCI values, the surgeons should consider finely adjusting the screws, plates, or wires if the situation allows.

The evaluation of clinical risk factors using logistic regression models was of great importance for determining the true predictive value of mTCI while minimizing the bias. Zheng et al[29] found that high-energy trauma dramatically increased the likelihood of severe elbow stiffness (30°< ROM ≤60°) (OR 4.45, $P = .03$) in 169 patients with elbow stiffness. Dickens et al[7] also stated that patients with high-energy open elbow fractures tended to suffer from a limited ROM and poor functional outcomes. In our study, a high-energy injury mechanism was found to be significantly associated with elbow stiffness. In addition, the injury to surgery time that is longer than 1 week also significantly correlated with elbow stiffness. Hong et al[13] found a markedly higher risk of clinically relevant HO in patients whose surgeries were performed on days 2-7 (OR 5.34, $P = .007$) and after 7 days (OR 7.88, $P = .002$) than in patients who underwent early-stage surgical treatment (≤24 hours). Wigger et al[28] also noted that the risk of post-traumatic elbow stiffness was 1.12 times higher for each additional day until surgical management was provided after the initial trauma. However, more prospective and multicenter clinical trials with a high level of evidence should be performed in the future to further validate these findings.

Our study had several limitations. First, our study was retrospective, which limited the variety and details of the analyzed variables. Second, although our sample size was relatively larger than that in previous studies, more data are required to further investigate the clinical value of these new measurements, and the proposed ranges associated with elbow stiffness required further validation. Third, only the AP view of radiographs were measured in our study, but postoperative computed tomographic scans, which may be more accurate in assessing articular reduction, were not evaluated. Also, the idea of using mTCI is to assess whether the surgeon has achieved a satisfactory bicolumnar structure that can only be visualized on the AP view; therefore, we did not analyze the lateral view, which may contain other information. Fourth, the films we measured were those taken immediately after the surgery and, through the healing process, the mTCI value may alter and thus affect the outcome. This study emphasized on the correlation between the initial mTCI and the outcome and proposed the possibility of readjustment of the fixation before skin closure. The alternation of mTCI in the healing process might be addressed in future cohort studies.

Conclusion

The malreduction of the medial column measured by mTCI-HA, mTCI-LHL, and mTCI-MHL was strongly associated with elbow stiffness in type C2-3 distal humeral fractures. All 3 parameters are reliable measuring methods, and the predictive value of mTCI-HA was better than that of the other 2 methods. Values beyond a certain range for each parameter significantly increase the risk of developing post-traumatic elbow stiffness. Patients who present with such postoperative radiographs should be managed with great caution, and certain interventions should be performed to minimize the negative influence. Also, we identified injury to surgery time longer than 1 week and high-energy trauma as independent risk factors of elbow stiffness.

Disclaimer

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