Late Dorsal Tilt Angulation of Distal Articular Surface of Radius in Colles' Type of Fracture at the End of the Immobilization, Can It Be Predicted?

Sukrom Cheecharern MD*

**Department of Orthopaedic Surgery, Rajavithi Hospital, College of Medicine, Rangsit University, Bangkok, Thailand*

Background: *The objective was to predict the late dorsal tilt angulation of distal articular surface of radius in Colles' type of fracture with radioulna index difference, age, sex of the patient and dorsal cortex comminution.*
Material and Method: *Correlation between previously mentioned factors and the changing degree of dorsal tilt angulation of distal articular surface of radius were analyzed. Sixty three wrist radiographs of sixty two patients with Colles' type of fracture were evaluated for dorsal tilt angulation of distal articular surface, radioulna index before and after reduction and at the end of the immobilization, dorsal cortex comminution after reduction. The interobserver and intraobserver generalizability coefficients of the dorsal cortex comminution measurement method were analyzed.*
Results: *Dorsal cortex comminution, age and sex of the patient were the predictors of the dorsal tilt angulation of distal articular surface of Colles' type of fracture at the end of the immobilization. Partial correlation coefficient for dorsal cortex comminution, age and sex were 0.177, 0.201 and -8.206 respectively. The generalizability coefficients were rated as substantial to excellent.*
Conclusion: *The late dorsal tilt angulation of distal articular surface of radius at the end of the immobilization can be predicted from size of dorsal cortex comminution, age and sex of the patients.*

Keywords: *Colles's fracture, Dorsal cortex comminution, Multiple regression*

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Dorsal tilt angulation of distal articular surface is one of the most common abnormal radiographic findings in healed extra articular fracture of distal radius[1]. Palmar tilt angle of distal articular surface is found to correlate with wrist dysfunction, such as pain and grip strength. Various risk factors have been studied for an association with redisplacement of extra articular fracture of distal radius such as initial dorsal tilt angulation of distal articular surface[1], dorsal cortex comminution[1-3], age[4,5] and sex of the patient[4,5]. Radial shortening was also reported as one of the risk factors[6]. The purpose of the present study was to correlate the size of dorsal cortex comminution, radioulna index difference, age and sex of the patient to the changing degree of dorsal tilt angulation of distal articular surface of radius in Colles type of fracture at the end of conservatively treated with short arm cast immobilization and construct the equation used to predict the redisplacement of dorsal tilt angulation of distal articular surface at the end of immobilization from size of dorsal cortical bone defect and age and sex of the patients.

The present study was approved by Rajavithi Hospital ethical committee.

Material and Method

An observational study was employed using patient records and randomly selected wrist radiographs as data sources. The database at a single instituition (Rajavithi Hospital, Bangkok, Thailand) was used to identify all patients with Colles type of fracture over the course of the last 3 years.

The inclusion criteria

Patients with extra articular fracture of distal radius and were successfully manipulated into either anatomic or acceptable position. Every fracture was immobilized in short arm cast for 4-6 weeks.

Correspondence to:
Cheecharern S, Department of Orthopaedic Surgery, Rajavithi Hospital, 2 Phyathai Road, Ratchathewi, Bangkok 10400, Thailand.
Phone: 0-2354-8108-37 ext. 2219
E-mail: sukrom@gmail.com

The exclusion criteria

Patients who had Colles' fracture with intra articular fracture line, irreducible fracture or failure immobilization and surgical intervention would be excluded.

The size of dorsal cortex comminution was measured in degree of angle formed by the lines joining dorsal and volar fracture sites of distal and proximal fragments[2]. The size of dorsal cortex comminution was measured from the lateral radiograph of the post-reduction Colles' type of fracture in every patient. To evaluate the generalizability of the proposed measurement method of dorsal cortex comminution, the other 14 lateral radiographs of post reduction and short arm cast immobilization of Colles' type of fracture were evaluated by 3 independent observers with a different level of orthopaedic experience, using the measurement method mentioned above, to measure the size of dorsal cortex comminution in degree in a blinded and randomized fashion. Repeat measurements were performed by the same observers in the next 2-4 weeks. Correlation coefficients were used as measurements of intraobserver and interobserver generalizability coefficients.

Statistical analysis

Multiple regression and multiple correlation analysis were used to predict the changing amount of dorsal tilt angulation of distal articular surface of radius from multiple independent variables. Sample size was calculated from the equation[7] :

$n = (Z_{1-\alpha/2} + Z_{1-\beta})^2/C\,(r)^2 + 3$

where $C\,(r) = 1/2 \log ((1 + r)/(1 - r))$

$\alpha = 0.05\ \beta = 0.9$

Pearson correlation from a pilot study for maximum sample size is 0.365 then n = 53 cases.

For the present study of p independent variables $n_p = n_1/(1- r^2_{1,2,3,4})$,

then $n_p = 62$ cases.

Correlation analysis of dorsal cortex comminution and dorsal tilt angulation of distal articular surface between observers were calculated. A $p < 0.05$ was set for statistical significant.

Results

Demographic and baseline data

Of 62 subjects (14 males and 48 females), one subject sustained both arm fractures, 63 Colles' type of fractures were included in the present study. The sex distribution for subjects was 21% males and 79% females. The average age was 53.51 $\pm$ 18.02 years old, ranged from 15 to 82 years old. Of the total number of 63 Colles' type of fractures treated, 50 fractures (79%) increased their dorsal tilt angulation of distal articular surface. The mean of redisplacement of dorsal tilt angulation of distal articular surface was 9.41 $\pm$ 9.96 degrees, ranged from -8 to 43 degrees.

The estimated size of dorsal cortex comminution measured was 19.73 $\pm$ 14.50 degrees, ranged from 0 to 55 degrees. Only dorsal cortex comminution, age and sex of the patient were the predictors of the dorsal tilt angulation of distal articular surface of Colles' type of fracture at the end of the immobilization. Partial correlation coefficient for dorsal cortex comminution was 0.177, for age was 0.201 and for the gender of the patient was -8.206 where 0 = male and 1 = female patient (Multiple coefficient correlation $R = 0.508$, $p < 0.001$).

The constructed equation used to predict the redisplacement of dorsal tilt angulation of distal articular surface at the end of immobilization from size of dorsal cortex comminution, and patients' age and sex was:

$$Y = 1.512 + 0.177\,x_1 + 0.202\,x_2 - 8.207\,x_3$$

Where y = redisplacement angle, measured in degree, of dorsal tilt angulation of distal articular surface at the end of immobilization

x_1 = size of dorsal cortex comminution

x_2 = age of the patients

x_3 = sex of the patients

The patients' demographic data, means and ranges of dorsal tilt angulation of distal articular surface of radius, radioulna index difference pre-, post-reduction and at the end of the immobilization and dorsal cortex comminution are demonstrated in Table 1.

According to quality of reduction, there was statistical significant difference between means of pre- and post-reduction of both dorsal tilt angulation of distal articular surface of radius and radioulna index. (Table 2).

According to redisplacement angle, measured in degree, of dorsal tilt angulation of distal articular surface at the end of immobilization there was statistical significance difference between means of post-reduction and bony union of both dorsal tilt angulation and radioulna index (Table 3).

Generalizability coefficients

From another set of 14 lateral radiographs of post reduction and short arm cast immobilization of Colles' type of fracture, there were statistical significant correlation coefficients in the size of dorsal cortex comminution measured in degree between three

Table 1. Baseline characteristic (n = 63)

	Female	Male
Age	56.49	43.07
Age group		
less than 60 years	26	9
60 years or more	23	5
Number/percent	49/79%	14/21%
Dorsal angulation;pre- reduction,degree		
Mean	14.76	14.93
Maximum	40	32
Minimum	-13	-7
Dorsal angulation; post- reduction, degree		
Mean	-0.20	-2.43
Maximum	13	13
Minimum	-9	-15
Dorsal tilt angulation; end of immobilization, degree		
Mean	8.27	10.29
Maximum	30	33
Minimum	-21	-16
Dorsal cortex comminution size, degree		
Mean	21.31	14.21
Maximum	55	37
Minimum	0	0
Radioulna index; pre- reduction, mm.		
Mean	2.27	2.48
Maximum	9.2	9.05
Minimum	-0.8	-1.6
Radioulna index; post- reduction, mm.		
Mean	-0.20	-2.34
Maximum	8.45	5.3
Minimum	-2.5	-1.6
Radioulna index; end of immobilization, mm.		
Mean	3.30	2.53
Maximum	13	9.8
Minimum	-8	-1.6

Table 2. Radiologic parameters concerning pre- and post-reduction

Radiologic parameters	Pre-reduction	Post-reduction	p-value
Dorsal angulation	14.79	-0.70	< 0.00
Radioulna index	2.32	1.34	< 0.00

Table 3. Radiologic parameters concerning post-reduction and end of immobilization

Radiologic parameters	Post-reduction	End ofimmobilization	p-value
Dorsal angulation	-0.70	8.71	< 0.000
Radioulna index	1.34	3.13	< 0.000

observers. The correlation coefficients of two measurements of each observers and correlation coefficients between observer of dorsal cortex comminution were rated as substantial to almost

perfect[8]. There were also statistical significant correlation coefficients in dorsal tilt angulation of distal articular surface measured in degree. The value of best correlation coefficients and ranges of correlation coefficients from three observers are demonstrated in Table 4.

Discussion

According to the size of dorsal cortex comminution, there was correlation between the size of dorsal cortex comminution and the redisplacement of dorsal tilt angulation of distal articular surface with the coefficient of partial correlation of 0.177. This result also confirmed the finding of other studies about dorsal cortex comminution and instability of Colles' type of fractures using different approaches[9].

According to age of the patients, there was correlation between the age of the patient and the redisplacement of dorsal tilt angulation of distal articular surface with the coefficient of partial correlation of 0.202.Age of the patient showed a higher figure than size of dorsal cortex comminution. The relationship between age of the patient and the redisplacement of dorsal tilt angulation of distal articular surface has been shown by many previous studies[4,5].

According to sex of the patients, there was correlation between the sex of the patient and the redisplacement of dorsal tilt angulation of distal articular surface with the coefficient of partial correlation of -8.207. It showed that sex of the patients is one of the predicting factors of redisplacement of dorsal tilt angulation of distal articular surface in Colles' fracture in which males had worse prognosis than females, in contrast to previous studies[4,5].

The radioulna index difference between pre- and post- reduction was not found to be one of the predicting factors. Radial axial shortening has been studied with a different methodology and found to be one of the predicting factors[6], not similar to the present study.

According to the generalizability coefficients test, the interobserver correlation coefficients of the size of dorsal cortex comminution measurement method were rated as substantial. When compared to the interobserver correlation coefficients of the dorsal tilt angulation of distal articular surface of radius measurement method which were rated as substantial to almost perfect, the proposed measurement method of dorsal cortex comminution was not as generalizable as the method used to measure the dorsal tilt angulation of distal articular surface of radius.

According to the intraobserver correlation coefficients of the three measurements of size of dorsal cortex comminution of each observer were rated as almost perfect. When compared to the intraobserver correlation coefficients of the dorsal tilt angulation of distal articular surface which were rated as substantial to almost perfect, the proposed measurement method of dorsal cortex comminution is as good as or better than the method used to measure the dorsal tilt angulation of distal articular surface of radius.

According to the blinding technic used for generalizability coefficients test, it does not represent the actual situation of radiographic evaluation. Normally the attending physician can evaluate both pre-reduction and post-reduction radiographs at the same time to identify even a minor fragment at the fracture site. Hence, the only single post-reduction radiographs measurement of dorsal cortex comminution in the present study might contribute to the lower value of generalizability coefficients than it actually would be.

Table 4. Generalizability coefficients

	Dorsal cortex comminution		Dorsal tilt angulation of distal articular surface	
Interobserver	correlation coefficients	Range	correlation coefficients	Range
First and second observer	0.642	0.537-0.642	0.801	0.642-0.801
First and third observer	0.851	0.728-0.851	0.757	0.622-0.757
Second and third observer	0.699	0.590-0.699	0.875	0.770-0.875
Intraobserver	correlation coefficients	p-value	correlation coefficients	p-value
First observer	0.82	< 0.001	0.887	< 0.001
Second observer	0.878	< 0.001	0.848	< 0.001
Third observer	0.922	< 0.001	0.696	0.006

According to the overall result of the conservative treatment of Colles' type of fracture with short arm cast, the mean of redisplacement angle was as high as 10 degree. Since some Colles' type of fractures could possibly turn from acceptable reductions into unacceptable ones at the end of the short arm cast immobilization, it would be of great benefit to use the gender specific normograms advocated by Cheecharen[2] to direct the initial treatment toward operative methods for those who deserved.

Conclusion

The dorsal tilt angulation of distal articular surface of radius in Colles' type of fracture at the end of the immobilization can be predicted from the size of dorsal cortex comminution measured in degree, age and sex of the patients since the beginning of the conservative treatment. The radioulna index difference did not have the coefficient of partial correlation with the dorsal tilt angulation of distal articular surface of radius in Colles' type of fracture at the end of the immobilization. The measurement method of dorsal cortex comminution was generalizable.

Potential conflicts of interest

None.

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การโก่งงอส่วนปลายกระดูกเรเดียสของผู้ป่วยกระดูกเรเดียสส่วนปลายหัก ชนิด Colles' fracture เมื่อสิ้นสุดการเข้าเฝือกสามารถทำนายได้ล่วงหน้าหรือไม่?

สุกรม ชีเจริญ

วัตถุประสงค์*: เพื่อศึกษาความสัมพันธ์ระหว่างภาวะการโก่งงอของส่วนปลายของกระดูก เรเดียส ในผู้ป่วยกระดูกเรเดียสส่วนปลายหัก ชนิด Colles' fracture เมื่อสิ้นสุดการรักษาด้วยการใส่เฝือก กับ เพศ อายุ และ radio-ulna index difference และขนาดของชิ้นกระดูก dorsal cortex comminution และเพื่อศึกษาหาความเชื่อถือได้ของการวัดขนาดของ ชิ้นกระดูก dorsal cortex comminution*

วัสดุและวิธีการ*: ภาพรังสีของข้อมือผู้ป่วยกระดูกเรเดียสส่วนปลายหักชนิด Colles' fracture ที่คัดเลือกมาอย่างสุ่ม จำนวน 63 ภาพ จากผู้ป่วย 62 ราย ได้นำมาวัดค่าภาวะโก่งงอของส่วนปลาย กระดูกเรเดียส ภายหลังการดึงกระดูกให้เข้าที่ ขนาดของ dorsal cortex comminution, ความแตกต่างของ radio-ulna index ก่อน และ หลัง การดึงกระดูกให้เข้าที่, เพศ และอายุของผู้ป่วย นำมาคำนวณหาค่าความสัมพันธ์กับค่าความโก่งงอ ของส่วนปลายกระดูกเรเดียสที่เพิ่มมากขึ้นตอนสิ้นสุดการรักษา ด้วยสัมประสิทธ์สหสัมพันธ์เชิงพหุ และหาความสอดคล้องกันของการวัดขนาดของ dorsal cortex comminution ระหว่างผู้วัดสามคน และผู้วัดคนเดียวกัน*

ผลการศึกษา*: ค่าความโก่งงอ ของส่วนปลายกระดูกเรเดียส ที่เพิ่มมากขึ้นเมื่อสิ้นสุดการรักษา มีความสัมพันธ์กับกับตัวแปรอิสระคือ ขนาดของ dorsal cortex comminution, อายุและเพศของผู้ป่วยโดยมีสัมประสิทธ์สหสัมพันธ์ตามลำดับดังนี้ 0.177, 0.201 และ -8.207 ค่าเฉลี่ยความสอดคล้องกันของการวัด ระหว่างผู้วัดต่างคน และการวัดซ้ำของผู้วัดคนเดียวกัน อยู่ในระดับมีน้ำหนักพอสมควรถึงดีเลิศ*

สรุป*: ค่าความโก่งงอ ของส่วนปลายกระดูกเรเดียส ที่เพิ่มมากขึ้นเมื่อสิ้นสุดการรักษา สามารถทำนายได้ด้วย ขนาดของ dorsal cortex comminution, เพศ และอายุของผู้ป่วย*