



Original article

What is the real angle of deviation of metacarpal neck fractures on oblique views? A radiographic study[☆]



Arthur de Góes Ribeiro^{a,*}, Daniel Hidalgo Gonzalez^a, João Manoel Fonseca Filho^a,
Guilherme Marques da Fonseca^a, Antonio Carlos Costa^{a,b}, Ivan Chakkour^a

^a Department of Orthopedics and Traumatology, Faculdade de Ciências Médicas da Santa Casa de São Paulo, São Paulo, SP, Brazil

^b Department of Orthopedics and Traumatology, Faculdade de Medicina do ABC, Santo André, SP, Brazil

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ABSTRACT

Objective: The aim of this study was to establish an indirect, easy-to-use, predictable and safe means of obtaining the true degree of displacement of fractures of the neck of the fifth metacarpal bone, through oblique radiographic views.

Methods: An anatomical specimen from the fifth human metacarpal was dissected and subjected to osteotomy in the neck region. A 1-mm Kirschner wire was fixed to the base of the fifth metacarpal bone, perpendicular to the longitudinal axis of the bone and parallel to the ground. Another six Kirschner wires of the same diameter were bent over and attached to the osteotomized bone to simulate fracture displacement. Axial rotation of the metacarpus was used to create oblique radiographic views. Radiographic images were generated with different angles and at several degrees of rotation of the bone.

Results: We deduced a mathematical formula that showed the true displacement of fractures of the neck of the fifth metacarpal bone by means of oblique radiographs.

Conclusions: Oblique radiographs at 30° of supination provided the best view of the bone and least variation from the real value of the displacement of fractures of the fifth metacarpal bone. The mathematical formula deduced was concordant with the experimental model used.

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[☆] Work performed in the Department of Orthopedics and Traumatology, Irmandade da Santa Casa de Misericórdia de São Paulo, São Paulo, SP, Brazil.

* Corresponding author.

E-mail: ribeiroesc@yahoo.com.br (A. de Góes Ribeiro).

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Qual é o ângulo real do desvio da fratura do colo do metacarpo nas incidências oblíquas? Estudo radiográfico

R E S U M O

Palavras-chave:
Fraturas ósseas
Mão
Metacarpo
Radiografia

Objetivo: Estabelecer uma forma indireta, fácil, previsível e segura na obtenção do valor real do desvio da fratura do colo do quinto metacarpo a partir de radiografias oblíquas.

Métodos: Uma peça anatômica de quinto metacarpo humano foi dissecada e submetida à ostectomia na região do colo. Um fio de Kirschner de 1 mm foi fixado perpendicular ao eixo longitudinal do osso e paralelo ao solo. Outros seis fios de Kirschner do mesmo diâmetro foram dobrados e presos ao osso ostectomizado para simular o desvio das fraturas. Rotação axial do metacarpo foi usada para criar as radiografias nas incidências oblíquas. Imagens radiográficas foram obtidas com diferentes ângulos e em vários graus de rotação do osso.

Resultados: Deduzimos uma equação matemática que demonstra o real desvio da fratura do colo do quinto metacarpo por meio de radiografias oblíquas.

Conclusões: A radiografia oblíqua com 30° de supinação apresenta melhor visualização do osso e menor variação do valor real do desvio da fratura do colo do quinto metacarpo. A fórmula matemática deduzida foi concordante com o modelo experimental usado.

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Introduction

Fractures of the neck of the fifth metacarpal result from direct axial or oblique trauma on this bone. They may be due to a fall or to receiving a blow. These fractures occur frequently in the general population and account for around 20% of all fractures of the hand.^{1,2}

Clinical evaluations on patients with these fractures take into consideration shortening, rotation and angular deviation during flexion.²⁻⁴

The reduction technique most used is the Jahss maneuver, which improves the degree of deviation of the distal fragment of the fracture.⁵

The decision to implement surgical treatment depends on clinical and radiographic parameters and also on the patient's age, profession, activity level and handedness.⁶

It has been recommended in the recent literature that radiographic assessments on these fractures should be conducted using anteroposterior, lateral and oblique radiographic views.⁵

It is known that the best way of evaluating the real angle of deviation of a fracture is by means of a radiographic view perpendicular to the fracture line.⁴ However, lateral radiographs are often limited because of superposition of the other metacarpals, the technical quality of the image, the presence of plaster-cast immobilization after the reduction and the printing on photographic paper.^{7,8} Tasbas et al.⁹ studied the influence of the radiographic method on the measurements obtained for analyzing these fractures.

The objective of the present study was to establish an easy-to-use, predictable and safe indirect method for ascertaining the real degree of deviation during flexion in fractures of the neck of the fifth metacarpal, through application in oblique-view radiographs, which provide a better view of the bone in question.

Material and methods

An anatomical review of the human fifth metacarpal was conducted in order to understand the spatial positioning of this bone in the hand.

After the fifth metacarpal of the donor cadaver had been dissected to remove soft tissues, it was subjected to wedge ostectomy in the neck region, with a volar basis. This resection was performed using an oscillating saw guided by a transfer system and enabled simulation of fractures with deviations of up to 90°.

A 1 mm Kirschner wire was attached to the base of the fifth metacarpal, perpendicular to the longitudinal axis of the bone and parallel to the ground. Another six wires of the same diameter, with predetermined angular measurements that would reproduce the deviation of the fracture during flexion, were then attached to the dorsal cortex of the bone (Fig. 1) and were maintained oriented orthogonally to the first wire.

The angles used to simulate fractures were 15°, 30°, 45°, 60°, 75° and 90° (Fig. 2). The axial rotation determined by the wire that was parallel to the ground was used to create oblique radiographic views at 0°, 15°, 30°, 45°, 60°, 75° and 90° (Fig. 1), which were established with the aid of a goniometer.

The bone was fixed using a 2 mm metal screw in a plastic support equipped with a goniometer (Fig. 1).

All the radiographs were produced with an X-ray beam parallel to the ground, at a distance of 1 m between the specimen and the device. We used a digital radiography machine (model RO 1750 ROT 360, Philips Medical Systems DMC GmbH, Hamburg, Germany), with parameters appropriate for radiographs of the hand (46 kV; 5.00 mAs; 20 ms). In this manner, images with a variety of angular deviations of the ostectomy and degrees of rotation were produced, which thus comprised oblique images (Fig. 3).

Table 1 – Angle of fracture, measured from oblique radiographic view.

Angle of fracture	Rotation of metacarpal						
	0 (L)	15°	30°	45°	60°	75°	90° (AP)
16°	16	15	15	12	9	5	0
29°	29	28	27	23	19	11	0
43.6°	43.6	43	40	34	25	14	0
58°	58	58	54	49	39	25	0
74°	74	73	71	64	57	38	0
89°	89	88	87	84	80	69	0

L, lateral view; AP, anteroposterior view.

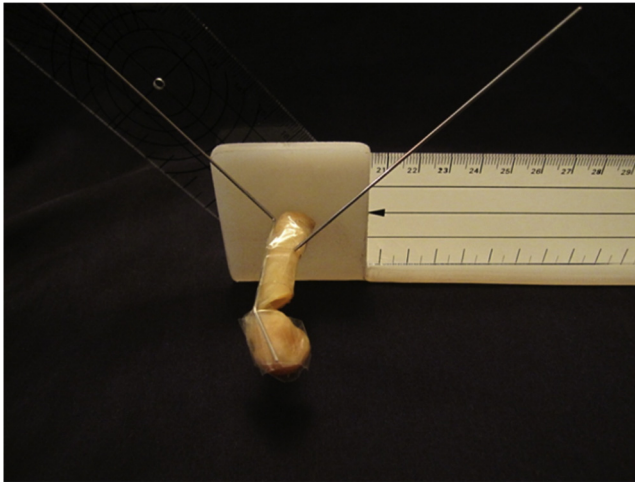


Fig. 1 – Device set up with goniometer, with the fifth metacarpal attached to a plastic support. Two 1-mm K wires were fixed to the bone: one of them perpendicular to the longitudinal axis of the bone and the other perpendicular to the first wire in order to simulate the angular deviation of the fragment.

The angles measured on the radiographs were assessed using the AutoCAD® software (Fig. 3). The values obtained are presented in Table 1 and Fig. 4.

We asked the Departments of Engineering of the Mackenzie Higher Education School (São Paulo, Brazil) and the University of Porto (Portugal) to research a formula that would represent the mathematical function of the real deviation of the fracture, from the deviations found on oblique radiographs, without having access to the practical results.

A new table and graph were drawn up using the values found through applying the mathematical formula (Table 2 and Fig. 5).

The tables and Figs. 4 and 5 were compared using the Microsoft Excel® software, in order to ascertain the degree of similarity. This confirmed the validity of the formula that had been elaborated.

In order to facilitate measurement of the real angle of deviation, we created a table showing oblique incidence values and measured angles. From this, the real values for fractures can be found without the need to enter the data in the formula (Table 3).

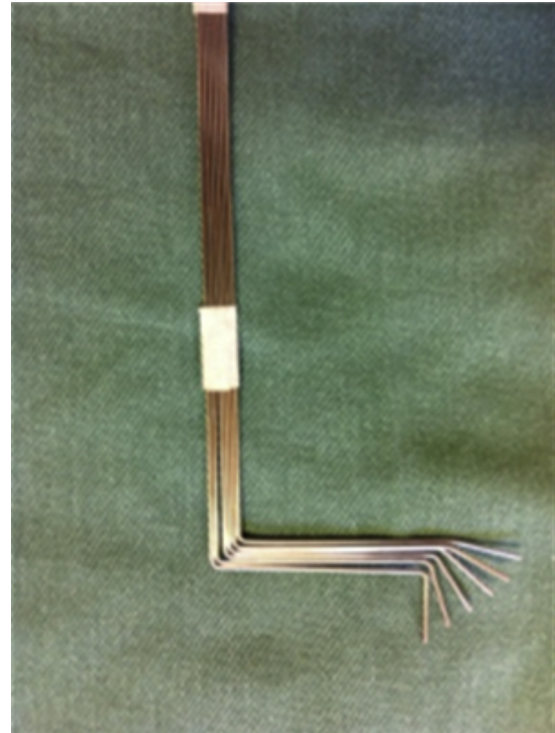


Fig. 2 – One-millimeter K wires bent at 15, 30, 45, 60, 75 and 90°.

A third mathematical study was conducted to correlate the proportions between the experimental values obtained from the radiographs and the real value of the fracture studied (Table 4).

Results

The values obtained are described in Table 1 and Fig. 4.

The two departments of engineering produced the same formula:

$$\gamma = \arctg \left(\frac{\text{tg} \beta}{\cos \alpha} \right)$$

In this formula, γ represents the value of the real angle; β represents the angle that is read and α represents the angle of radiographic incidence on the bone, which is equivalent to the angle of axial rotation of the metacarpal in the experiment.

Table 2 – Real angle of fracture, from the formula applied to the oblique radiographic view.

Angle of fracture	Rotation of metacarpal						
	0 (L)	15°	30°	45°	60°	75°	90° (AP)
16°	16	15	14	11	8	4	0
29°	29	28	26	21	15	8	0
43.6°	43.6	43	40	34	25	14	0
58°	58	57	54	49	39	22	0
74°	74	73	72	68	60	42	0
89°	89	89	89	89	88	86	0

L, lateral view; AP, anteroposterior view.

Table 3 – Real angle of fracture, according to the angle measured from the oblique radiographic view.

Measured angle (in degrees)	Rotation of the hand (in degrees)																		
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90
5	5	5	5	5	5	6	6	6	7	7	8	9	10	12	14	19	27	45	90
10	10	10	10	10	11	11	12	12	13	14	15	17	19	23	27	34	45	64	90
15	15	15	15	16	16	16	17	18	19	21	23	25	28	32	38	46	57	72	90
20	20	20	20	21	21	22	23	24	25	27	30	32	36	41	47	55	64	77	90
25	25	25	25	26	26	27	28	30	31	33	36	39	43	48	54	61	70	79	90
30	30	30	30	31	32	32	34	35	37	39	42	45	49	54	59	66	73	81	90
35	35	35	35	36	37	38	39	41	42	45	47	51	54	59	64	70	76	83	90
40	40	40	40	41	42	43	44	46	48	50	53	56	59	63	68	73	78	84	90
45	45	45	45	46	47	48	49	51	53	55	57	60	63	67	71	75	80	85	90
50	50	50	50	51	52	53	54	55	57	59	62	64	67	70	74	78	82	86	90
55	55	55	55	56	57	58	59	60	62	64	66	68	71	74	77	80	83	87	90
60	60	60	60	61	62	62	63	65	66	68	70	72	74	76	79	82	84	87	90
65	65	65	65	66	66	67	68	69	70	72	73	75	77	79	81	83	85	88	90
70	70	70	70	71	71	72	73	73	74	76	77	78	80	81	83	85	86	88	90
75	75	75	75	75	76	76	77	78	78	79	80	81	82	84	85	86	87	89	90
80	80	80	80	80	81	81	81	82	82	83	84	84	85	86	87	87	88	89	90
85	85	85	85	85	85	85	86	86	86	86	87	87	87	88	88	89	89	90	90
90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90	90

Table 4 – Percentage difference between the measurements obtained from the oblique radiographic view and the real angle from the lateral view of the distal fragment of the fifth metacarpal.

Angle of distal fragment	Rotation of metacarpal						
	0	15°	30°	45°	60°	75°	90° (F)
16°	100%	94%	94%	75%	56%	31%	0%
29°	100%	97%	93%	79%	66%	38%	0%
43°	100%	98%	91%	78%	58%	32%	0%
58°	100%	100%	93%	84%	67%	43%	0%
74°	100%	99%	96%	86%	77%	51%	0%
89°	100%	99%	98%	94%	90%	78%	0%

The values obtained when applied to the formula, for the different angles of rotation of the metacarpal, are shown in [Table 2](#) and [Fig. 5](#).

To facilitate deducing the real angle of flexion, a table with oblique incidence values and measured angles was created. From this, the real deviation value for the fractures can be accessed without the need to use the formula ([Table 3](#)).

To evaluate the relationship between the values obtained using the various oblique views and the real values (lateral view) of the deviation during flexion, [Table 4](#) was created.

Discussion

In treating fractures of the neck of the fifth metacarpal, doubtful cases in which the fracture cannot be seen well on radiographic images are faced. Thus, it is important to have options that provide reliable information, so that decisions made can be as correct as possible.

It is recognized that all methods of radiographic evaluation on fracture deviation need to be reproducible and accurate.⁵

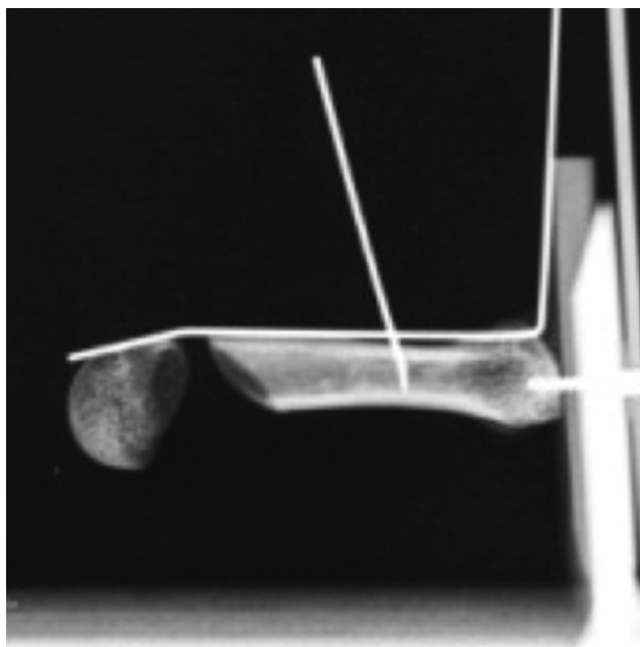


Fig. 3 – Radiographic image of the device used.

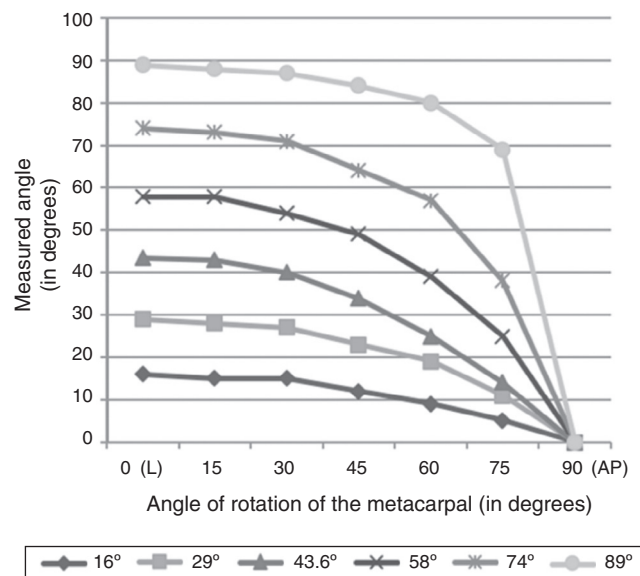


Fig. 4 – Variations of the angles measured, according to the axial rotation of the metacarpal. L, lateral view; AP, anteroposterior view.

It has been recommended in the recent literature that deviation of fractures of the fifth metacarpal should be measured by means of an angle traced out between the diaphysis and head, in lateral and oblique views.³

Some studies have presented attempts to define radiographic parameters and measurements on the fifth metacarpal that would be routinely applicable, but without great success. This was probably due to the complex anatomy of this bone and the acceptance of an average of up to 40° of angular deviation for indicating conservative treatment for these fractures.^{3,4,7,10}

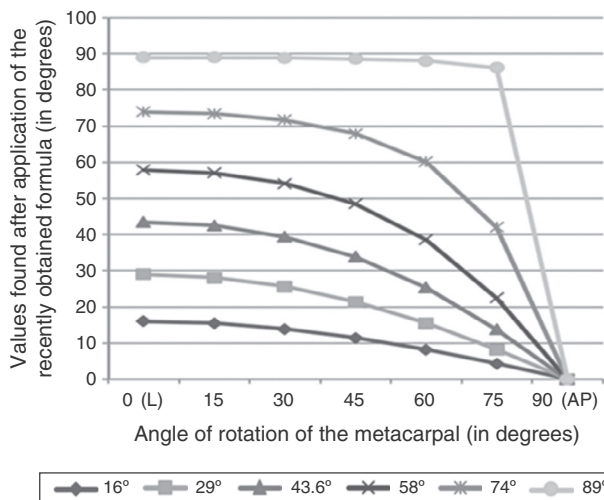


Fig. 5 – Variations of the angles obtained after application of the formula that was calculated. L, lateral view; AP, anteroposterior view.

Because of the difficulty in evaluating preoperative and post-reduction cases, as well as those for which conservative treatment is used, a need to seek alternatives for quantifying the real angular deviation between the fracture fragments of this bone, with as great a degree of certainty as possible despite the limitations, has arisen.

However, there are no articles in the literature on standardization of angular measurements on oblique radiographs. For this reason, we made measurements at oblique angles by means of axial rotation of the metacarpal, in steps of 15°.

In evaluating the radiographs obtained, measurements using AutoCAD® were made on the lines projected from the Kirschner wires. The bone was used as a guide for fixation of the wires and as a means of familiarization with the images of the fracture (Fig. 6).

We firstly noted that radiographs with a rotation of 30° provided the best view of the bone, with the least distortion of the real angular value, in comparison with the other oblique views (Fig. 7). From analysis on radiographs with 30° of supination and pronation of the hand, we observed that there was least bone superposition at the incidence with 30° of supination of the hand. There was up to 91% agreement between the real angular value of the fractures and the radiographic measurements at the oblique position of 30° (Table 4).

Oblique radiography is a method that enables measurement of the angular deviation that is more trustworthy. However, management decisions are made based on the real angular deviation of the fracture. Through using the formula proposed here, the real deviation of the fracture can be inferred from measurements on the oblique incidence.

The results from this study show the differences between angle measurements in the lateral and oblique views, for the same fracture, in the same way as previously reported in the literature^{3,10} (Table 1).

Because of the complexity of the mathematical formula, we drew up a conversion table from which the real values of fracture deviations can be obtained. Through using this table,

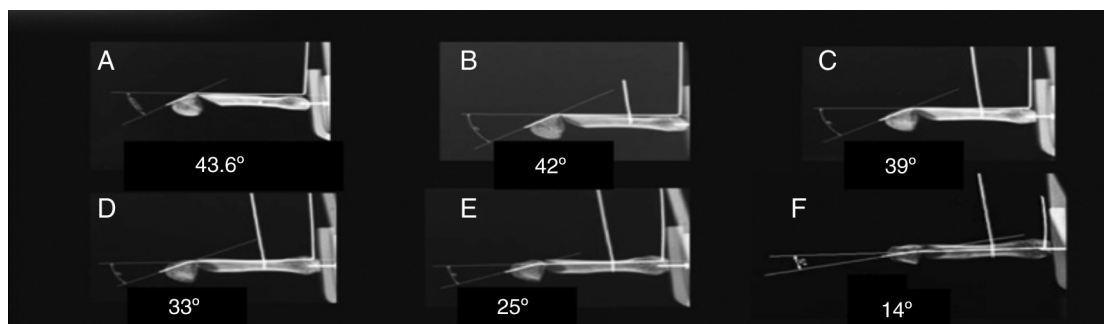


Fig. 6 – Angles measured on oblique radiographs of the fifth metacarpal, with 45° of deviation of the distal fragment during flexion. A, lateral view; B, 15° of axial rotation; C, 30° of axial rotation; D, 45° of axial rotation; E, 60° of axial rotation; F, 75° of axial rotation.



Fig. 7 – Radiographs of normal hand. A, with 30° of supination; B, lateral view; C, with 30° of pronation.

conservative treatment of fractures can be accepted when oblique-view radiographs at 30° of supination show an angular deviation value of up to 35°, which represents real deviation of 39° (Table 3).

The economic importance of this assessment method can also be highlighted, given that the need for lateral radiographs for the initial evaluation of the fracture can be dismissed. Furthermore, the patients are less exposed to radiation.

Since the trigonometric analysis was based on projection of images from Kirschner wires, we can infer that the applicability of the formula extends to fractures of other long bones.

We consider that the limitations of this study were its use of a commercial goniometer and the possible imprecision of radiographs and in the molding of the metal wires. Moreover, this experiment was performed with only one bone, which was not equivalent to the specific spatial bone organization of a hand. Further radiographic studies are needed in order

to evaluate the applicability of the formula that was obtained through clinical practice.

We believe that our use of the AutoCAD® software for measuring the angles increased the degree of certainty of the measurements.

Conclusion

There was a constant relationship between the real deviation of the fracture and the radiographic angle in fractures of the metacarpals. The mathematical formula that was derived was consistent with the experimental model used.

Conflicts of interest

The authors declare no conflicts of interest.

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