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Diagnostic Failure Rate in Detecting Perilunate Carpal Fractures and Dislocations Using Plain Wrist X-Rays*

Índice de falha diagnóstica na detecção de fraturas e luxações perilunares do carpo utilizando radiografias simples do punho

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Abstract

Objectives The present study aimed to evaluate the diagnostic failure rate in detecting perilunate fractures and dislocations using plain wrist radiographs by orthopedists and orthopedic residents. A secondary objective was to identify possible groups with a greater or lesser chance of establishing a correct diagnosis.

Methods An online questionnaire was sent to several orthopedists through e-mail, social networks, and smartphone-based communication applications to assess the rate of diagnostic failure in detecting perilunate fractures and dislocations using plain radiographs.

Results A total of 511 responses was obtained, with a diagnostic error rate of 8.81% for simple dislocations and 1.76% for trans-scaphoid perilunate fractures. Group stratification showed that residents presented the highest error rates in simple perilunate dislocations (23.91%), whereas hand surgeons presented the lowest error rates (1.74%).

Conclusion Compared with the literature, the failure rates found were lower, suggesting that plain radiography is effective and that the error rate may not be as high as reported.

Keywords
- carpal bones/injuries
- wrist injuries
- joint dislocations
- fractures, bone

* *Study performed at Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo, Ribeirão Preto, SP, Brazil.*

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Resumo

Objetivos O presente estude teve como objetivo avaliar o índice de falha diagnóstica na detecção de fraturas e luxações perilunares do carpo utilizando radiografias simples do punho por ortopedistas e residentes de ortopedia. Secundariamente, identificar possíveis grupos que apresentem maior ou menor chance de acerto diagnóstico.

Métodos Foi aplicado um questionário online a diversos ortopedistas através de e-mail, redes sociais e aplicativos de comunicação via *smartphone*, para avaliar o índice de falha diagnóstica na detecção de fraturas e luxações perilunares utilizando radiografias simples.

Resultados Foram obtidas 511 respostas e observado um índice de erro diagnóstico de 8,81% para as luxações simples e 1,76% para fratura transescafoperilunar. Ao estratificar por grupos, os médicos residentes obtiveram os maiores índices de erro nas luxações perilunares simples (23,91%), já os cirurgiões de mão obtiveram os índices mais baixos (1,74%).

Conclusão Ao comparar com a literatura, os índices de falha encontrados foram menores, sugerindo que a radiografia simples é eficaz e que o índice de erro pode não ser tão elevado quanto o relatado na literatura.

Palavras-chave

- ossos do carpo/lesões
- traumatismos do punho
- luxações articulares
- fraturas ósseas

Introduction

Wrist perilunate fractures and dislocations are uncommon conditions, corresponding to approximately 7% of all carpal injuries.[1] These lesions have serious repercussions for affected patients if not properly diagnosed and treated. Perilunate fractures and dislocations are caused by high-energy traumas, such as car accidents, falls from height and contact sports, and they are often associated with other traumatic injuries. Patients present with diffuse wrist pain, edema, loss of range of motion and fingers in a semi-flexed position. Subjects may also complaint of paresthesia in the median nerve territory and acute carpal tunnel syndrome.[2]

Radiographic evaluation is essential to manage these patients, and posteroanterior (PA) and lateral (L) views are sufficient for diagnosis. Posteroanterior radiography with ulnar deviation of the wrist helps to assess trans-scaphoid perilunate fracture-dislocations.[2] On PA radiography, it is important to observe Gilula lines, which are imaginary lines drawn through the proximal and distal aspects of the proximal row and the proximal aspect of the distal row. These three lines should be smooth, parallel arches, and breaks suggest carpal incongruity.[3] Lateral radiographies show the alignment of the capitate, lunate and radius bones. These bones must be properly aligned, and any alignment change strongly suggests a perilunate dislocation. Computed tomography scans can be useful when there are associated complex fractures, such as scaphoid and pyramidal fractures, and they must be performed after dislocation reduction.[4]

In 1980, Mayfield et al.[5] performed a cadaveric study and classified this condition in four progressive stages. An axial force was applied with wrist hyperextension associated with ulnar deviation and intercarpal supination to reproduce the injury. In stage I, they observed scapholunate ligament rupture or scaphoid fracture. In stage II, a lunate-capitate subluxation was observed, and some cases may present capitate fractures. Stage III was characterized by lunate-pyramidal ligament injury or pyramidal fracture, with a dorsal perilunate dislocation of the entire carpus. Stage IV presented palmar lunate dislocation towards the carpal tunnel when the capitate is reduced to the lunate fossa.[5]

Due to the low frequency of these injuries and low familiarity of most orthopedists with the complex anatomy of carpal bones, perilunate dislocations often are not diagnosed at the first visit.[1,2] In a multicenter study with 166 patients, Herzberg et al.[6] demonstrated that diagnosis was not made at the initial evaluation in 25% of the cases of simple dislocations and trans-scaphoid lunate fracture-dislocations. This data is troublesome, since early diagnosis and treatment are critical to minimize serious complications such as stiffness, chronic pain and posttraumatic arthrosis.[2,4,7,8] In addition, treatment delay was shown to negatively impact the final outcome.[6,9]

This reality reported by international studies does not seem to be different from the Brazilian reality. Our service, which specializes in hand surgery, receives many patients with chronic perilunate dislocations who were not properly diagnosed at a first orthopedic visit, affecting the treatment outcome.

The present study aimed to evaluate the failure rate in perilunate fractures and dislocations diagnosis using plain wrist radiographs by orthopedists and orthopedic residents. In addition, this study attempted to identify possible groups presenting a greater or lesser chance of a correct diagnosis.

Materials and Methods

An online questionnaire was prepared and applied using the Google Forms platform (Google LLC, Menlo Park, CA, USA) [10] and sent to orthopedists and orthopedic residents through e-mail, social networks (Workplace from Facebook [Facebook Inc., Menlo Park, CA, USA] from *Sociedade Brasileira de Ortopedia e*

Traumatologia [SBOT]), and smartphone-based communication applications (WhatsApp [Facebook Inc.]). These platforms were chosen because they can provide a wide reach for the questionnaire and provide a convenient way for orthopedists and orthopedics residents to answer it. The questionnaire consisted of four initial questions to analyze the profile of the study subjects. These questions were related to time (in years) since medical residency, area of activity, SBOT accreditation, and work in urgency/emergency units for patients with upper limb trauma. In the second stage of the questionnaire, eight PA and lateral radiographs of the wrist were shown, with three normal images and five with pathological findings. Pathological radiographs include a simple perilunate dislocation, a perilunate fracture-dislocation, a scaphoid fracture, and two images showing a distal radial fracture. After analysis, professionals answered whether the radiograph was normal or if there was a fracture and/or dislocation. Radiographs were presented in a random order. Questionnaires answered in an incomplete or contradictory way were excluded. A chi-square test was used to verify the association between qualitative variables. In addition, this association was quantified using logistic regression models[11] to calculate the gross odds ratio (OR) and their respective 95% confidence intervals.

This work was approved by the institutional ethics committee under CAAE number 84365318.3.0000.5440.

Results

A total of 511 responses were obtained. Of these, 194 (38%) orthopedists had more than 10 years of experience, 225 (44%) had less than 10 years of experience, and 92 (18%) were residents. Of the 419 trained orthopedists, 352 (84%) were accredited by the SBOT, and 67 (16%) did not have a specialist title recognized by SBOT. In addition, among these 419 orthopedists, 172 (41%) work in hand surgery, 90 (21.5%) are general orthopedists, and 157 (37.5%) work as specialists in other areas, such as spine, knee, and shoulder. Of the 511 professionals, 436 currently work in an emergency unit treating upper limb trauma (85.3%).

►**Figure 1** shows a radiograph from a simple, Mayfield stage III perilunate dislocation. The diagnostic error rate was 8.81%. This error rate was 23.91% among residents and 5.49% among trained orthopedists (►**Figure 2**). The chance of a resident missing a diagnosis (OR) was 4.3 times higher compared to orthopedists with more than 10 years of experience and 6.7 times higher compared to orthopedists with less than 10 years of experience. When compared by surgical area, hand surgeons had the lowest error rate, of 1.74%. The chance of a general orthopedist and a specialized orthopedist making a mistake was about 5 times higher compared to hand surgeons (OR 0.211 and 0.197, respectively). Comparing residents with hand surgeons, the chance of error was about 17.5 times higher (OR 0.057). P values were lower than 0.001 (►**Table 1**).

The radiograph from ►**Figure 3** shows a stage III transscaphoid perilunate fracture. The global diagnostic error rate was 1.76%. Error rate was 7.61% among residents and 0.48% among orthopedists (►**Figure 2**). This represents an OR of 9.1 for orthopedists with less than 10 years of experience and 3.6 for general orthopedists, with a p-value < 0.001. All orthopedists with more than 10 years of experience, hand surgeons, and specialized orthopedists correctly diagnosed this radiography (►**Table 2**).

There were no relevant differences between trained orthopedists with SBOT, accreditated or not. As for the

Fig. 1 Perilunate dislocation, Mayfield stage III.

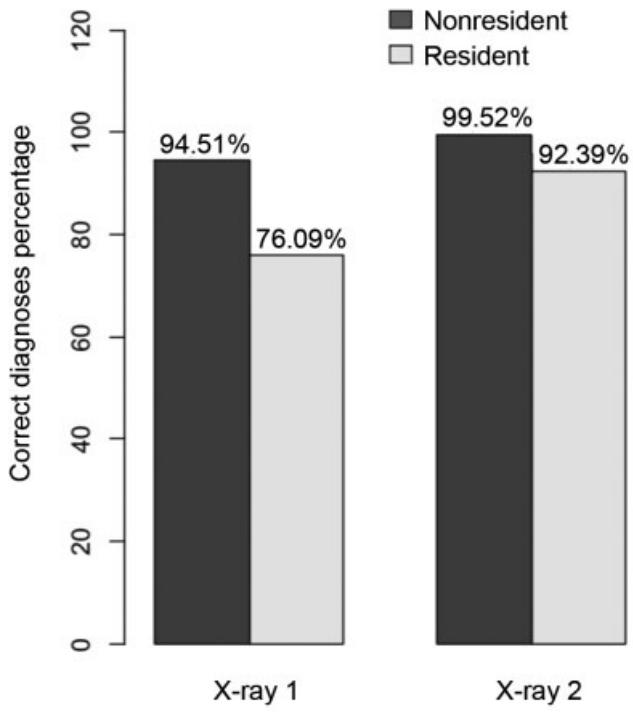

Fig. 2 Correct diagnoses percentage: Residents versus Nonresidents.

normal radiographs presented in the questionnaire, 38.49% of the answers classified them as pathological.

Discussion

There was a very significant number of responses, with good participation from the orthopedic community. The 511 responses obtained correspond to approximately 3% of Brazilian orthopedists.[12] However, this was a convenience sample, which may limit the external validity of the study and may not necessarily be representative of all geographic regions of the country.

Most articles regarding the diagnostic failure rate in simple or complex perilunate dislocation cite a study from Herzberg et al.,[6] performed in Europe in 1993. These authors reported a 25% rate, with no discrimination between simple and complex dislocations. In a more recent study published in Turkey in 2018, there was a 22.7% rate of diagnostic failure in 44 patients with perilunate dislocation or fracture-dislocation. The only risk factor found was the orthopedist inexperience with the condition. Among the surgeons missing the diagnosis, 70% said it was the first time they encountered this condition.[13] Another recent study, published in 2018, evaluated perilunate dislocation and fracture-dislocation in a population of military personnel in the United States and found a diagnostic failure at

Table 1 Frequencies and logistical regression for X-ray 1

	X-ray 1					
	Miss (0)	Hit (1)				
	n (%)	n (%)	Total	*p*-value*	Gross odds ratio	Confidence interval (95%)
Question 1: What is your current degree?						
1	13 (2.54)	181 (35.42)	194 (37.96)	< **0.001**	4.376	**(2.090–9.163)**
2	10 (1.96)	215 (42.07)	225 (44.03)		6.757	**(3.052–14.958)**
3	22 (4.31)	70 (13.70)	92 (18.00)		1.000	Reference
Question 2: What is your area of expertise?						
1	3 (0.59)	169 (33.07)	172 (33.66)	< **0.001**	1.000	Reference
2	7 (1.37)	83 (16.24)	90 (17.61)		0.211	**(0.053–0.835)**
3	13 (2.54)	144 (28.18)	157 (30.72)		0.197	**(0.055–0.704)**
4	22 (4.31)	70 (13.70)	92 (18.00)		0.057	**(0.016–0.195)**
Question 3: Are you an orthopedist/traumatologist accredited by *Sociedade Brasileira de Ortopedia e Traumatologia* (SBOT)?						
1	19 (3.72)	333 (65.17)	352 (68.88)	< **0.001**	5.508	**(2.831–10.719)**
2	4 (0.78)	63 (12.33)	67 (13.11)		4.950	**(1.618–15.147)**
3	22 (4.31)	70 (13.70)	92 (18.00)		1.000	Reference
Question 4: Do you currently work in an urgency/emergency unit for upper limb trauma orthopedic treatment?						
1	37 (7.24)	399 (78.08)	436 (85.32)	0.5382	1.288	(0.575–2.886)
2	8 (1.57)	67 (13.11)	75 (14.68)		1.000	Reference

*p-value for Chi-square test. Modeled probability 1 = hit.
Question 1. 1: I completed my residency more than 10 years ago; 2: I completed my residency less than 10 years ago; 3: I am a resident in orthopedics and traumatology.
Question 2. 1: Hand surgery; 2: General orthopedics; 3: Other areas (e.g., knee, hip, spine surgery); 4: I am a resident physician in orthopedics and traumatology.
Question 3. 1: Yes; 2: No; 3: I am a resident physician in orthopedics and traumatology.
Question 4. 1: Yes; 2: No.

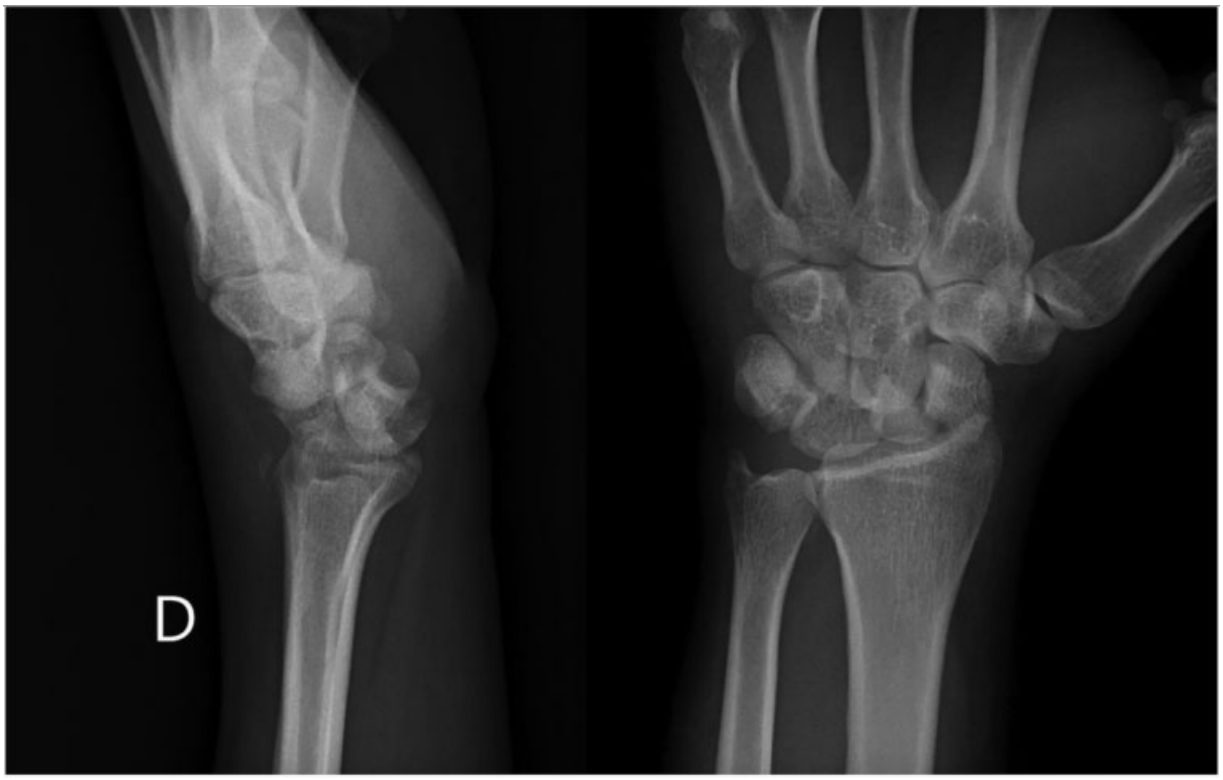

Fig. 3 Trans-scaphoid lunate fracture-dislocation, Mayfield stage III.

Table 2 Frequencies and logistical regression for X-ray 2.

	X-ray 2					
	Miss (0)	Hit (1)				
	n (%)	n (%)	Total	*p*-value*	Gross odds ratio	Confidence interval (95%)
Question 1: What is your current degree?						
1	0 (0.00)	194 (37.96)	194 (37.96)	< **0.001**	–	–
2	2 (0.39)	223 (43.64)	225 (44.03)		9.182	**(1.870–45.082)**
3	7 (1.37)	85 (16.63)	92 (18.00)		1.000	Reference
Question 2: What is your area of expertise?						
1	0 (0.00)	172 (33.66)	172 (33.66)	< **0.001**	–	–
2	2 (0.39)	88 (17.22)	90 (17.61)		3.624	(0.732–17.938)
3	0 (0.00)	157 (30.72)	157 (30.72)		–	–
4	7 (1.37)	85 (16.63)	92 (18.00)		1.000	Reference
Question 3: Are you an orthopedist/traumatologist accredited by *Sociedade Brasileira de Ortopedia e Traumatologia* (SBOT)?						
1	1 (0.20)	351 (68.69)	352 (68.88)	< **0.001**	28.906	**(3.509–238.094)**
2	1 (0.20)	66 (12.92)	67 (13.11)		5.435	(0.653–45.274)
3	7 (1.37)	85 (16.63)	92 (18.00)		1.000	Reference
Question 4: Do you currently work in an urgency/emergency unit for upper limb trauma orthopedic treatment?						
1	7 (1.37)	429 (83.95)	436 (85.32)	0.5187	1.679	(0.342–8.241)
2	2 (0.39)	73 (14.29)	75 (14.68)		1.000	Reference

*p-value for Chi-square test. Modeled probability 1 = hit.
Question 1. 1: I completed my residency more than 10 years ago; 2: I completed my residency less than 10 years ago; 3: I am a resident in orthopedics and traumatology.
Question 2. 1: Hand surgery; 2: General orthopedics; 3: Other areas (e.g., knee, hip, spine surgery); 4: I am a resident physician in orthopedics and traumatology.
Question 3. 1: Yes; 2: No; 3: I am a resident physician in orthopedics and traumatology.
Question 4. 1: Yes; 2: No.

initial care in 27.5% of cases.[14] We found significantly lower error rates, of 8.81% for simple perilunate dislocations and 1.76% for perilunate fractures-dislocations. Such results may be due to a high suspicion rate among orthopedists, who, feeling observed and tested, may have changed their behavior for fear of making mistakes. This is indicated by findings of fractures or dislocations in 38.49% of the answers related to normal radiographs. Another aspect interfering with the diagnostic accuracy rate is the time the patient was seen in the emergency room and the amount of rest the doctor had.[13,15] In Turkey, Çolak et al.[13] reported that 70% of patients diagnosed incorrectly were admitted to the emergency room at night. The design of our study did not allow an analysis of this variable, which is a particular feature of the clinical practice.

It should also be considered that the questionnaire does not correspond to the clinical practice, in which it is possible to take the history and perform a physical examination of the patient, generating a greater or lesser index of suspicion for a given condition depending on the clinical findings. However, our study may suggest that the diagnostic failure rate is not as high as previously thought and that the European study from Herzberg et al.[6] does not represent the Brazilian reality. Another hypothesis is that errors may be decreasing due to the improved training of physicians in residency programs since 1993, when Herzberg's study was carried out. One aspect that corroborates this last hypothesis is that there was a significant difference between resident doctors and trained orthopedists (23.9% versus 5.49%), thus demonstrating that the orthopedics and traumatology residency is effective in instructing residents to identify this condition on plain radiographs.

Hand surgeons had the lowest error rates, as expected, due to their greater familiarity with the condition. In contrast, SBOT accreditation as a specialist was not related to differences in the correct diagnosis rate.

Our study indicates that the diagnostic error rate for perilunate dislocations may be lower than that described in the classical literature. However, this statement requires studies with a higher level of scientific evidence in order to be confirmed. A suitable option would be a multicenter case-control study, as it reflects clinical practice with greater reliability and provides a satisfactory number of cases, since perilunate dislocations are not common and one hospital alone could bias the study due to its specific demographic features.

Conclusion

The diagnostic error rate of plain radiographs was 8.91% for isolated perilunate dislocations and 1.76% for perilunate fractures-dislocations, suggesting that this is an effective method and that the error rate may not be as high as expected. Hand surgeons and orthopedic residents, respectively, presented the lowest and highest diagnostic error rates.

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Conflict of Interests
The authors declare that there is no conflict of interests.

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