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Relationship between carpal bone morphology and scaphoid fracture location

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Abstract

Aim: Morphological variations in carpal bone may affect wrist pathologies. In this study, we examined the relationship between carpal bone morphologies and scaphoid fractures.

Materials and Methods: Patients with a prominent scaphoid fracture on posteroanterior and ulnar deviation X-rays were included in the study. Morphological types of lunate, hamate, capitate, presence of capitate-fourth metacarpal joint, and scaphoid fracture location were documented retrospectively. A total of 68 patients, 65 (95.6%) male, and 3 (4.4%) female were included in the study.

Results: Considering the scaphoid fracture types, 40 (58.8%) patients had waist fractures, and 28 (41.2%) patients had proximal pole fractures. The association of fracture type and morphology of carpal bones was examined.

Conclusion: In our study, we found that lunate, capitate, hamatum morphology and ulnar variance, fourth metacarpal articulation did not affect the scaphoid fracture pattern.

Introduction

Carpal joints are a complex structure consisting of eight bones and ligaments. Morphological variations in bone structure may affect wrist pathologies. There are many publications in the literature on carpal bones and their pathological effects [1].

Lunate bone has an important place in wrist biomechanics. Accordingly, there are many studies on lunate morphology. Lunate morphology was divided into three different types by Antuna-Zapico (A-Z) [1,2]. In A-Z type 1, the angle between the proximal part of the lunate and articulating with the scaphoid is greater than 130 degrees. In A-Z Type 2, this angle is below 130 degrees. A-Z type 3 has two different facets that articulate with radius and TFCC. Viegas divided the lunate into two types based on their distal articular morphology. Type I lunate articulates with capitate only, while type II lunate articulates with capitate and hamate [2] (Figure 1 and Figure 2). There are various publications in the literature on the morphological types of the lunate bone and its effect on scaphoid bone pathologies [3,4,5].

The hamatum is divided into two sub-morphological types according to the presence of grooves. Type I hamate does not have a groove. Type II hamatum has a groove where it articulates with the triquetrum [6]. There is no study in the literature reporting the effect of hamate morphological type on wrist pathomechanics. The capitate is morphologically divided into three subtypes [7]. Horizontal lunate articular surface is classified as flat, articular surface V-

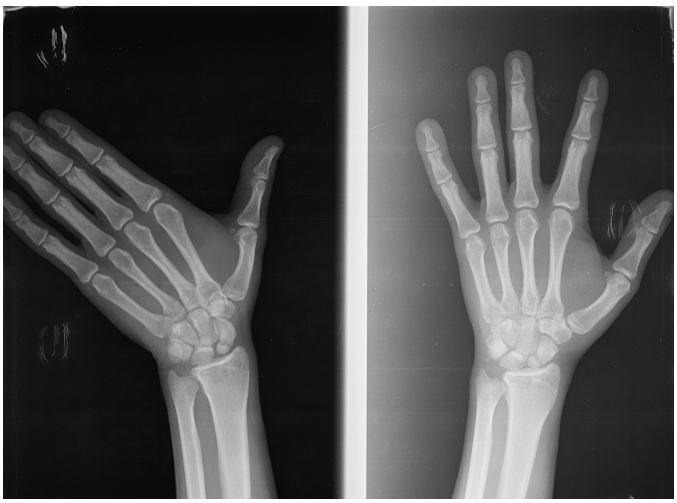

Figure 1. Type-II lunate with scaphoid proximal pole fracture.

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Figure 2. Type-II hamate with scaphoid proximal pole fracture.

type with a separate ridge for scaphoid and lunate, and S-type with a convex surface (Figure 3).

The relationship between the fourth metacarpal and capitate joint was studied by Viegas [8]. Morphologically, it is divided into five different subtypes in cadaver dissections. While all types articulate with hamate, some types articulate with both hamate and capitate (Figure 4). However, these subtypes cannot be detected on X-ray film. In the X-ray film, it can only be seen whether it forms a joint with the capitate in addition to the hamatum. Clinically, the axial load on the hand is transferred to the carpal bones by the metacarpals. There is an additional load sharing in the fourth metacarpals that articulate with the capitate.

Ulnar variance and its effects are a frequently researched topic in the literature (Figure 5). Many studies have been carried out, especially on Kienböck's disease and ulnar variance [9,10,11]. In addition, there are studies on ulnar variance and scaphoid pathologies in the literature [12,13,14]. Scaphoid fractures are divided into tubercle, distal, waist, and proximal pole fractures [15].

Figure 3. Flat type capitate with scaphoid proximal pole fracture.

In this study, we examined the relationship between carpal bone morphologies and scaphoid fractures. Carpal bone morphology is a frequently studied topic in the current literature. Examining whether this morphological diversity affects scaphoid pathologies will enable us to understand wrist pathologies in more detail.

Materials and Methods

This study was carried out in a tertiary hospital between January 2017 and February 2021 on patients' images. Before the study, Sancaktepe Prof. Dr. Ethical approval was obtained from the ethics committee of Ilhan Varank Training and Research Hospital (date: 17.11.2021 number: 2021/228). Patients with a diagnosis of scaphoid fracture (S62.0) and a prominent scaphoid fracture on posteroanterior (PA) and ulnar deviation X-ray were included in the study. Patients with peri lunate fracture, dislocation, and distal radius fracture, and patients with scaphoid fractures evident only on MRI and CT were not included in the study. Three patients whose distal pole fractures were not apparent on X-ray and only seen on MRI were not included in the study.

The age, gender, and side information of the patients were recorded. Morphological types of lunate, hamate, capitate, presence of capitate-fourth metacarpal joint, and scaphoid fracture location were documented. Lunate morphology was determined on a standard PA wrist X-ray film. If it articulated only with the capitate, it was considered type I according to Viegas, and type II if it articulated with the capitate and the hamatum. Lunat was also divided into three groups according to A-Z classification on standard AP X-ray film. The proximal part of the capitate was classified on standard AP X-Ray film according to whether it was flat, spherical, or V-type. The hamatum bone was

Figure 4. Capitate and 4.metacarpal articulation with scaphoid proximal pole fracture.

Figure 5. Ulnar positive variance with scaphoid waist fracture.

recorded as type I if there is no groove where it articulates with the triquetrum on standard AP radiographs, and type II if there is a groove. Likewise, the presence of the fourth metacarpal and capitate joint was evaluated on a standard AP wrist X-ray. Scaphoid fracture location was evaluated in both standard wrist AP and ulnar deviation X-rays.

Statistical analysis

In the descriptive statistics of the data, mean, standard deviation, median minimum, maximum, frequency, and ratio values were used. Distribution of variables Kolmogorov Smirnov measured by the test. The mann-whitney u test was used in the analysis of quantitative independent data. The chi-square test was used in the analysis of qualitative independent data, and the Fischer test was used when the chi-square test conditions were not met. SPSS 27.0 program was used in the analysis.

Results

A total of 68 patients, 65 (95.6%) male, and 3 (4.4%) female were included in the study. According to Viegas, 11 (16.2%) patients had type I lunate and 57 (83.6%) patients had type II lunate. When evaluated according to the Lunat A-Z classification, 28 (41.2%) patients were A-Z type I, 32 (47.1%) patients were A-Z type II, and 8 (11.8%) patients were A-Z type III. When the sub-morphological types of hamate were examined, 12 (17.6%) patients were identified as type I and 56 (82.4%) patients as type II. The capitate bone was divided into three sub-morphologies. When the capitate morphological types of the patients were examined, it was found as Flat 44 (64.7%), Spherical 20 (29.4%), and V-Shaped 4 (5.9%). When the capitate bone and fourth metacarpal articulation were examined, 63 (92.6%) patients had joints, and 5 (5.9%) patients had no joints. The ulnar variance was negative in 9 (13.2%) patients, positive in 6 (8.8%) patients, and neutral in 53 (77.9%) patients. Considering the scaphoid fracture types, 40 (58.8%) patients had waist fractures and 28 (41.2%) patients had proximal pole fractures. (Table 1) The relationship between scaphoid bone fracture location of these morphological subtypes in carpal bones is summarized in Table 2.

Discussion

In our study, all sub-morphological types of carpal bones were evaluated and it was examined whether there was an effect on the scaphoid bone fracture location. However, no significant link was found between morphological subtypes and fracture localization. Publications showing the effect of lunate morphology on scaphoid fractures are particularly noteworthy. Elsaftawy et al showed in their study that patients with scaphoid fractures mostly have type II lunate morphology [16]. Haase et al found no significant relationship between lunate morphology and scaphoid fracture localization in their study [17]. However, they revealed that patients with type II lunate morphology had less dorsal intercalated segment instability (DISI) deformity. Hein et al found no significant relationship between scaphoid fracture localization and lunate morphology [4].

Table 1. Demographic information, morphological information and scaphoid fracture types.

		Min-Max	Median	Mean±sd/n%
Age		16 - 59	28.0	29.7 ± 10.1
Gender	Male			65 95.6%
	Female			3 4.4%
Side	Right			37 54.4%
	Left			31 45.6%
Lunate Joint Type (Viegas)	I			11 16.2%
	II			57 83.8%
Lunate Type (A-Z)	A-Z I			28 41.2%
	A-Z II			32 47.1%
	A-Z III			8 11.8%
Hamate Type	I			12 17.6%
	II			56 82.4%
Capitate Morphology	Flat			44 64.7%
	Spherical			20 29.4%
	V-Shaped			4 5.9%
Capitate and 4. Metacarpal Artıculation	Available			4 5.9%
	Unavaible			63 92.6%
Ulnar Variance	(-)			9 13.2%
	(+)			6 8.8%
	N			53 77.9%
Fracture Pattern	Waist			40 58.8%
	Proximal			28 41.2%

Table 2. Comparison of scaphoid fracture pattern and carpal bone morphology.

		Waist Fracture			Proximal Pole Fracture			p
		Mean±sd/n%		Median	Mean±sd/n%		Median	
Age		29.5 ± 10.2		29.0	29.9 ± 10.2		26.0	0.842[m]
Gender	Male	37	92.5%		28	100.0%		0.263 X^2
	Female	3	7.5%		0	0.0%		
Side	Right	24	60.0%		13	46.4%		0.269 X^2
	Left	16	40.0%		15	53.6%		
Lunate Joint Type (Viegas)	I	6	15.0%		5	17.9%		0.753 X^2
	II	34	85.0%		23	82.1%		
(A-Z) Lunate Type	A-Z I	14	35.0%		14	50.0%		0.379 X^2
	A-Z II	20	50.0%		12	42.9%		
	A-Z III	6	15.0%		2	7.1%		
Hamate Type	I	7	17.5%		5	17.9%		0.970 X^2
	II	33	82.5%		23	82.1%		
Capitate Morphology	Flat	23	57.5%		21	75.0%		0.137 X^2
	Spherical	15	37.5%		5	17.9%		0.080 X^2
	V-Shaped	2	5.0%		2	7.1%		1.000 X^2
Capitate and 4. Metacarpal Artıculation	Available	4	10.0%		0	0.0%		0.134 X^2
	Unavaible	35	87.5%		28	100.0%		
Ulnar Variance	(-)	4	10.0%		5	17.9%		0.615 X^2
	(+)	4	10.0%		2	7.1%		
	N	32	80.0%		21	75.0%		

m Mann-whitney u test/ X^2 Chi-square test (Fischer test). Min: Minimum, Max: Maximum, Med:Medium, sd: Standard Deviation.

However, the risk of scaphoid nonunion was found to be higher in patients with type II lunate morphology. In our study, similar to the literature, no significant relationship was found between lunate morphology and fracture localization. In addition, all the mentioned studies examined the relationship between fracture localization and lunate morphology according to the Viegas classification. In our study, we also examined lunate morphology according to Antuna-Zapico (A-Z) types, and we could not find a significant relationship between this classification and fracture localization. Our study also revealed that there is no relationship between lunate morphology and scaphoid fracture localization, which supports the current literature.

Hamatum and capitatum pathologies are not as common as scaphoid and lunate pathologies. In this direction, there are not many publications in the literature investigating the effect of hamatum and capitatum morphology on the wrist. McLean et al., in an anatomical study, divided the hamatum into 2 morphological types according to the joint made with the triquetrum [6]. It has been emphasized that these 2 different types of hamatum show different kinematic properties. However, it has been mentioned that different studies are needed to show its effect on wrist pathologies. Yazaki et al divided capitate into 3 different morphological types [7]. He stated that these morphological types will affect carpal kinematics and may have an effect on wrist pathologies. In scapholunate dissociation, the proximal migration of the distal row may be less in V-type capitate and scapholunate advanced collapse may be less common. He also hypothesized that the association of scaphoid nonunion and V-type capitate is less likely to be posttraumatic arthritis. However, the effect of capitate morphology on the scaphoid fracture type was not mentioned. In our study, we revealed that sub-morphological types of capitate and hamatum do not affect the scaphoid fracture pattern.

The articulation between the fourth metacarpal and the hamatum-capitatum contains significant variations. Viegas et al. showed 5 different types of fourth metacarpal articulation in their cadaveric study [8]. However, these morphological variations could not be shown on X-ray film. Only the presence or absence of the fourth metacarpal-capitate joint is shown on X-ray film. They examined the relationship between the presence of this joint and ulnar variance but found no correlation. The most common mechanism of fracture of the scaphoid is falling on the open hand. The force generated during this trauma is transmitted to the carpal bones by the metacarpals. We examined the effect of the fourth metacarpal transmitting its load only through the hamatum or the hamatum-capitum on the fracture pattern. In our study, we revealed that there is no relationship between the presence of this joint and the scaphoid fracture pattern.

There are many publications in the literature on ulnar variance. Jafari et al showed in their study that the risk of scaphoid nonunion is higher in patients with ulnar negative variance [18]. Similarly, Palmero et al. showed that negative ulnar variance is a risk factor for scaphoid nonunion in their studies [19]. However, Rogalski et al found in their study that ulnar variance was not effective in the development of scaphoid nonunion [20].

Czitrom et al showed that there is a correlation between posttraumatic scapholunate disassociation and negative ulnar variance [21]. Despite these publications showing the effects of ulnar variance on scaphoid pathologies, we could not find a relationship between scaphoid fracture pattern and ulnar variance in our study.

Carpal bone morphologies and their pathomechanics effects are frequently studied subjects in the literature. In particular, the effect of lunate morphology and ulnar variance on Kienböck's disease has been frequently discussed. In our study, we found that lunate, capitate, hamatum morphology and ulnar variance, fourth metacarpal articulation did not affect the scaphoid fracture pattern.

Ethical approval

For this study ethical approval was obtained from the ethics committee of Sancaktepe Prof. Dr. Ilhan Varank Training and Research (Hospital date: 17.11.2021 number 2021/228).

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