

A Retrospective Study of Radiographic Anatomy of Wrist in Chinese Population

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Abstract

In wrist pathology, there is a need to establish the normal range of radiographic measurement parameters. Previous study showed that the contralateral wrist might not be valid as a reference for all parameters. There is a lack of literature describing the normal range of wrist radiographic parameters in literature. As a result, a retrospective study was carried out. Patients who underwent standard wrist x-rays during the period February 2012 to February 2013 (one single year) were retrospectively reviewed. 71 patients were included. Scapholunate angle was $54.7^\circ (\pm 6.5^\circ)$. Scapholunate interval was 2.0 mm (± 0.4 mm). Ulnar variance was +1.0 mm (± 1.8 mm). Carpal height was 31.8 mm (± 3.0 mm). Radial inclination was $25.1^\circ (\pm 2.1^\circ)$. All 71 patients had 1 sesamoid bone at first metacarpal. 16.9% (12 out of 71) patients had positive cortical ring signs. All these parameters are valuable clinically, especially in monitoring of the wrist disease progression, in the design of wrist implants and for future clinical research.

Keywords

Radiographic Anatomy, Wrist, Chinese

1. Introduction

Patients with a history of wrist sprain or injury can have disabling results such as carpal dissociation, and scaphoid tilt. The subtle changes in wrist x-rays can be very difficult to interpret. In the evaluation of wrist x-rays, there are radiographic indices which help to have an objective assessment of the condition. In unila-

teral wrist pathology, the normal side is commonly used as a reference. However, this may not be valid for all indices. Previous study showed that in unilateral wrist diseases, the normal wrist can be used as reference value for carpal angles, but it does not provide a better reference than normal values obtained from databases for ulnar variance [1]. It is therefore a need to establish the normal reference values for the commonly used wrist radiographic indices.

The scapholunate angle is formed by the intersection of the longitudinal axes of the scaphoid and lunate. An abnormal scapholunate angle is associated with carpal instabilities. Widened scapholunate interval is suggestive of scapholunate dissociation [2]. Negative ulnar variance is associated with Kienbock's disease [3], scaphoid fracture [4] and carpal ligamentous disruptions [5]. The cortical ring sign is present when the distal tubercle of the scaphoid is seen end on a PA projection of the wrist and this suggests that the scaphoid is flexed.

Previous studies had addressed the normal dimensions of radiographic indices in wrist x-ray of western population [6] [7]. However, there is no study which attempted to define the normal range and inter-observer reliability of the commonly used indices in Chinese population. We therefore conduct a retrospective study to define the normal range and inter-observer reliability of common wrist radiographic indices in the Chinese population.

2. Materials and Methods

Patients who underwent standard wrist x-rays during the period February 2012 to February 2013 (one single year) were retrospectively reviewed. Standard wrist x-rays were defined by the followings:

1) Posteroanterior (PA) view:

- 1) ulnar styloid outer margin collinear with the outer margin of ulna bone;
- 2) the long axis of 3rd metacarpals should be parallel to the long axis of the distal radius to ascertain neutral radial and ulnar deviation;
- 3) overlapping of pisiform and triquetral.

2) Lateral view:

- 1) long axis of third metacarpal should be coaxial with the long axis of radius;
- 2) palmar cortex of the pisiform bone overlies the central third of the interval between the palmar cortices of the distal scaphoid pole and the capitate head.

Exclusion criteria included patients who had surgical history over the wrist, who had known history of wrist arthritis or trauma (from clinical notes), or patients who had wrist fracture or dislocation.

The following radiographic parameters were measured:

- 1) Scapholunate angle (SL angle)

This is defined as the angle between the longitudinal axes of the scaphoid and lunate. Scaphoid axis is defined as the line through the midpoints of its proximal and distal poles. Lunate axis is defined as the perpendicular to a line joining the distal palmar and dorsal borders of the lunate bone (**Figure 1**).

- 2) Scapholunate interval (SL interval) was measured at the mid-scapholunate joint distance (**Figure 2**).

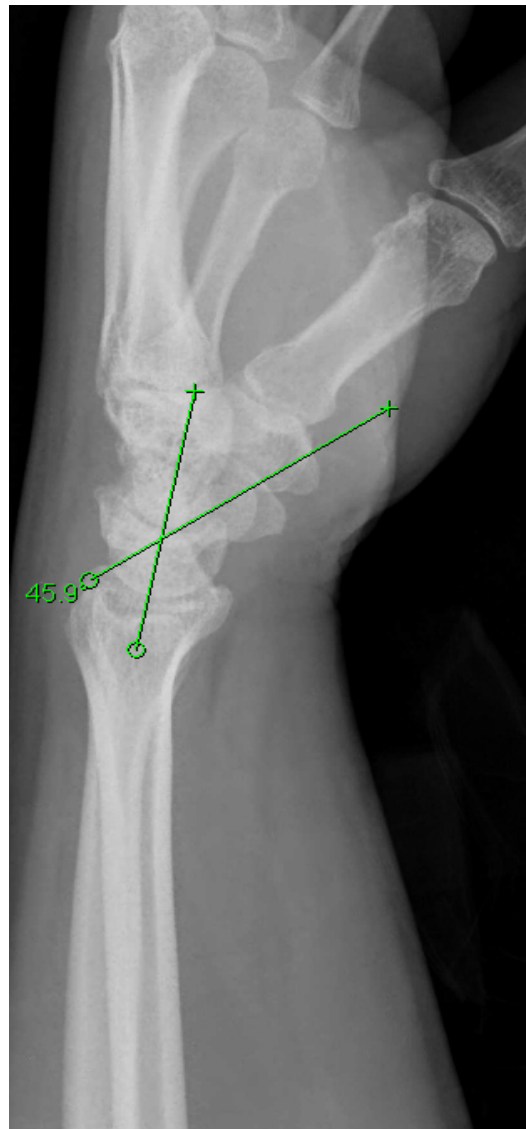


Figure 1. Measurement of scapholunate angle.

3) Ulnar variance (**Figure 3**)

A line was first drawn along the longitudinal axis of radius. Then, a line was drawn at the apex of the cortical rim of distal ulnar aspect of the radius and another line at the apex of the distal cortical rim of ulna, both of which were perpendicular to the first line. The distance between these two lines were then measured [8].

4) Carpal height

Using the axis of third metacarpal, carpal height is measured as the distance between base of third metacarpal to distal articular surface of radius (**Figure 4**).

5) Radial inclination

It is defined as the angle between one line connecting the radial styloid tip and the ulnar aspect of the distal radius and a second line perpendicular to the longitudinal axis of the radius (**Figure 5**).



Figure 2. Measurement of scapholunate interval.

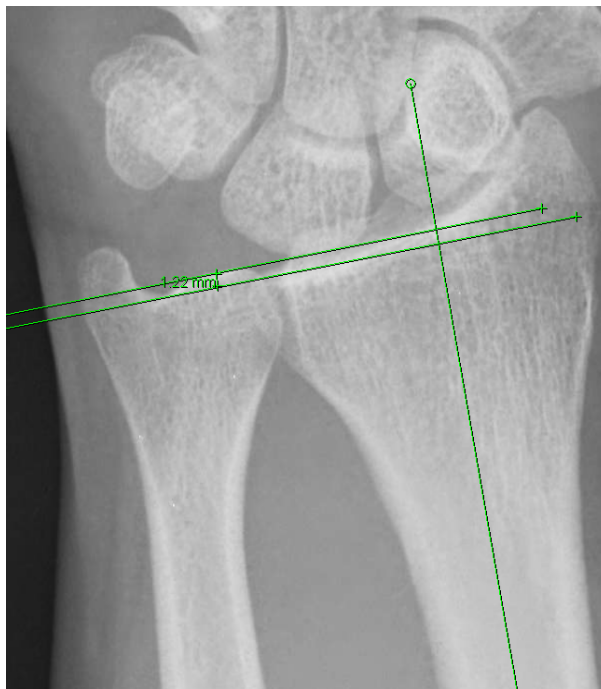


Figure 3. Measurement of ulnar variance.

- 6) Presence of sesamoid bone
- 7) Presence of cortical ring sign

Three independent observers measured the x-ray parameters and the interobserver error was calculated.



Figure 4. Measurement of carpal height.

3. Results

At baseline, 71 patients were included (30 males, 41 females). Mean age was 56.0 (± 13.8) years old. 57.7% (41 out of 71 patients) were x-rays of right wrists while 42.3% (30 out of 71 patients) were x-rays of left wrists. All of the indications for the wrist x-ray were wrist pain.

Scapholunate angle was 54.7° ($\pm 6.5^\circ$). Scapholunate interval was 2.0 mm (± 0.4 mm). Ulnar variance was +1.0 mm (± 1.8 mm). Carpal height was 31.8 mm (± 3.0 mm). Radial inclination was 25.1° ($\pm 2.1^\circ$). All 71 patients had 1 sesamoid bone at first metacarpal. 16.9% (12 out of 71) patients had positive cortical ring signs.

There was no significant difference for the following parameters in right wrist when compared to left wrist, namely, SL angle ($p = 0.46$), SL interval ($p = 0.94$), ulnar variance ($p = 0.74$), carpal height ($p = 0.62$), radial inclination ($p = 0.35$), presence of cortical ring sign ($p = 0.75$).

There was no significant difference in the SL angle ($p = 0.48$), SL interval ($p = 0.84$), ulnar variance ($p = 0.35$), radial inclination ($p = 0.49$), nor the presence of

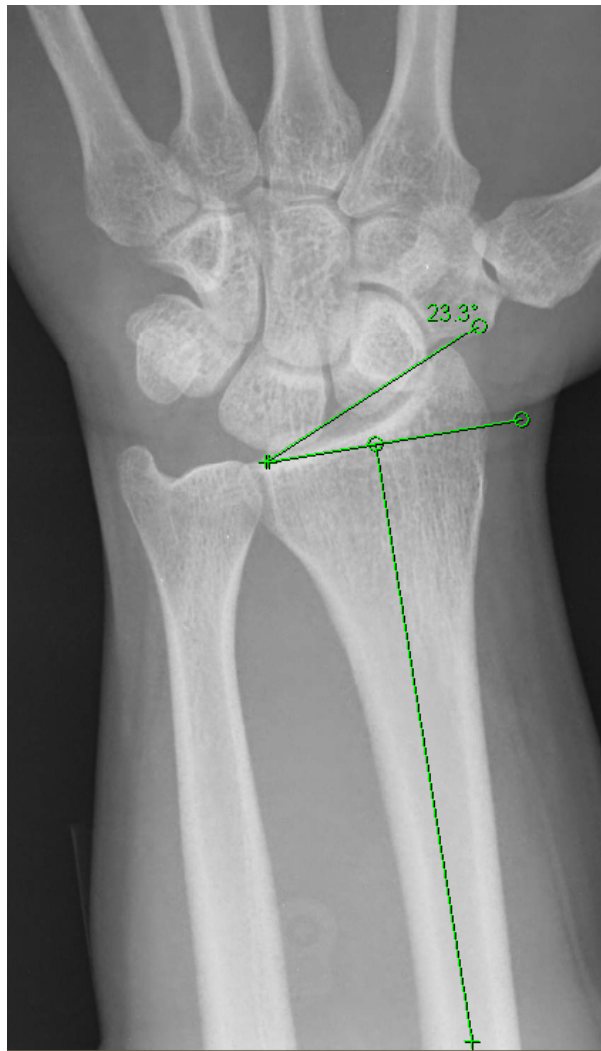


Figure 5. Measurement of radial inclination.

cortical ring sign ($p = 1.0$). However, male subjects had a higher carpal height 34.0 mm (± 2.4 mm), while female subjects had lower carpal height of 30.2 mm (± 2.4 mm).

There was no significant relation of age with regards to the SL angle ($p = 0.77$), SL interval ($p = 0.12$), ulnar variance ($p = 0.83$), carpal height ($p = 0.90$), radial inclination ($p = 0.82$), nor the presence of cortical ring sign ($p = 0.15$).

The intraclass correlation coefficients (ICC) were high for the following measurements: 0.79 for scapholunate angle, 0.85 for ulnar variance, 0.96 for carpal height and 0.76 for radial inclination. It was moderate for scapholunate interval (0.50) and poor for cortical ring sign (0.42).

4. Discussion

This is the first study to delineate the normal range of commonly used radiological indices in the Chinese population. All of the indices were comparable to similar studies in western population [6] [7]. Besides establishing the normal

range of radiographic parameters in wrist x-ray, the interobserver reliability was also investigated.

A large scapholunate angle (>70 degrees) was considered to be highly suggestive of increased flexion, or rotatory subluxation of the scaphoid [9]. Abnormal SL angle could also be seen in carpal instabilities, collapse or distal radius fracture with malunion [6]. The scapholunate angle was 54.7° ($\pm 6.5^\circ$) in our series. In contrast to previous study [1], the SL angle did not change with patient's age.

Gilula and Weeks¹⁰, by taking measurement of the middle of the SL joint, reported that an SL interval of <2 mm was normal, greater than 4 mm was pathologic, and between 2 and 4 mm is a finding of uncertain importance, which could be either normal, or pathological. The scapholunate interval was 2.0 mm (± 0.4 mm), which concurred with Gilula's findings [10]. The interobserver reliability was moderate for SL interval in our series, which was similar to the literature [11].

Positive ulnar variance was associated with more loading over scaphoid fossa of distal radius, whereas negative ulnar variance was associated with more loading over lunate fossa of distal radius [12]. Negative ulnar variance was found to be associated with Kienbock's disease in a number of studies previously [13] [14]. Majority of our Chinese population had positive ulnar variance with the measurement of $+1.0$ mm (± 1.8 mm). This length relationship needed to be taken into account during open reduction of distal radius or ulna fracture.

Carpal height objectively measured the amount of carpal collapse. Carpal collapse was also an important determinant of whether the lunate could be reconstructed in Kienbock's disease [15]. The lunate could be protected or reconstructed when there was no carpal collapse; otherwise procedures such as proximal row carpectomy had to be performed [15]. Carpal height was 31.8 mm (± 3.0 mm) in our series, and was lower in female when compared to male. This result could serve as a reference for carpal height monitoring.

Radial inclination was one of the parameters to assess the quality of reduction in distal radius fracture. Decrease in radial inclination had been shown to increase stiffness of distal radioulnar joint (DRUJ) in neutral, pronation and supination position in cadaveric study [16]. Increase stiffness of distal radioulnar joint would cause increased risk of DRUJ arthritis [17]. In our series, radial inclination was 25.1° ($\pm 2.1^\circ$).

Sesamoid bone around metacarpal could be one of the sources of pain. Pathologies included fracture and arthritis. Pain usually responded to sesamoidectomy after failed conservative treatment [18]. All patients in this study had 1 sesamoid bone at first metacarpal, which could make this population prone to sesamoid-related pathology.

The scaphoid cortical ring sign, identified as a radiological indicator of rotary subluxation of the scaphoid, was frequently seen on normal wrist x-rays. A study examined the clinical significance of this sign in 139 normal wrists in 114 patients, with a mean age of 52 (range 15 - 81) years. There were no significant relationships between the appearance of a cortical ring sign and age, gender or

hand dominance. Consequently, a cortical ring sign indicated scaphoid flexion, but may be visible in the normal wrist at any age or gender and in either hand and was not necessarily an indicator of pathology in the wrist [19]. In our series, 16.9% (12 out of 71) patients had positive cortical ring signs. The interobserver reliability was poor for this measurement among the three observers. Currently there was no study which investigated into the interobserver error for cortical ring sign. The author postulated that the poor reliability of this sign might be partially contributed by the nature of this sign: it was a morphological description of a ring and was subjected to the interpretation by the observer. On the other hand, other parameters such as carpal height would be more objective as they had exact numerical measurement. Further parameters should be designed to assess scaphoid flexion in PA view. In the lateral view, increased scapholunate angle could give a clue that the scaphoid was relatively flexed in relation to lunate.

Limitation of the study included that this is a retrospective study with limited sample size. Retrospectively reviewing the x-rays that were taken due to wrist pain might create some selection bias. This was minimized by excluding patients with surgical history over the wrist, who had known history of wrist arthritis or trauma (from clinical notes), or patients who had wrist fracture or dislocation. Future studies should involve prospective study to include healthy volunteers to establish the range of radiographic parameters. However, this would include radiation risk to normal subjects.

5. Conclusion

In conclusion, this study served as a database of the normal range regarding radiographic parameters of wrist anatomy in Chinese population. This can be used as future clinical research, to monitor the wrist disease progression and in the design of wrist implants.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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