

Research Paper: The Inter- and Intra-observer Reliability of Three Methods for Evaluating Carpal Collapse



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ABSTRACT

Background: Kienbock's disease is a rare and debilitating condition. The decision for surgical intervention majorly depends on the extent of the carpal collapse. Therefore, the accurate measurement of carpal collapse is of critical importance.

Objectives: The current study assessed the inter and intra-observer reliability of the three most frequent methods in measuring carpal height and determining carpal collapse.

Methods: Fifty-Nine photocopied radiograms were reviewed by three observers (one senior orthopedic resident, one fellowship-trained hand surgeon, and one senior radiology resident) at 3 consecutive time points. Besides, one-week intervals were considered between the evaluations. The evaluated measures included the Carpal Height Ratio (CHR), Revised Carpal Height Ratio (RCHR), and Capitate-Radius (CR) index. The reliability of the measurements in determining the carpal height was examined using the Intraclass Correlation Coefficient (ICC). The agreement of the measures on determining the presence or absence of the carpal collapse was assessed by Cohen's Kappa (K) value.

Results: The overall inter and intra-observer reliability of the CR index in quantifying the carpal collapse was measured as 0.863 and 0.942, respectively. The overall inter and intra-observer reliability of CHR in quantifying the carpal collapse was computed to be 0.615 and 0.891, respectively. The overall inter and intra-observer reliability of RCHR in quantifying the carpal collapse equaled 0.412 and 0.792, respectively. The overall K for determining the presence or absence of a carpal collapse was calculated as 0.776, 0.683, and 0.549 for CR index, CHR, and RCHR, respectively.

Conclusion: The CR index is the most reliable approach to measure carpal height. Furthermore, it is appropriate for determining the presence or absence of carpal collapse.

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1. Introduction

Osteonecrosis of the lunate, known as Kienböck's disease, is a rare and debilitating condition with poorly understood etiology [1-3]. Repetitive microtrauma is referred to as the major extrinsic risk factor of Kienböck's disease [4, 5]; such characteristics as a shortened ulna, lower number of arteries, reduced radial inclination angle, and type I lunate morphology are the intrinsic risk factors of this disorder [4, 6].

Carpal collapse is an essential diagnostic finding in Kienböck's disease. Besides, the decision for surgical intervention is generally based on the presence of this measure [7-9]. Several methods are introduced for this measurement, including the Carpal Height Ratio (CHR) [1, 2], Revised Carpal Height Ratio (RCHR) [3], and the Capitate-Radius (CR) index [4]. All methods were described as reliable by the original authors; however, identifying the most reliable approach for carpal collapse evaluation is necessary. The study aimed to evaluate the inter and intra-rater reliability of three introduced carpal collapse measurements (CHR, RCHR, & CR distance) to introduce the most reliable method for future workouts.

2. Methods

Sixty radiograms from patients with different stages of Kienböck's disease were scanned and printed by a single printer, 3 of each were in actual size. Three observers contributed to this study, including one orthopedic resident with 3 years of experience (observer 1), one fellowship-trained hand surgeon (observer 2), and one senior radiology resident with 4 years of experience (observer 3). The observers evaluated the carpal collapse on each radiogram using the 3 different methods (CHR, RCHR, & CR index). The CHR was regarded as the ratio obtained from dividing the carpal height by the length of the third metacarpal [10] (Figure 1a). The RCHR was regarded as the ratio obtained from dividing the carpal height by the capitate length (Figure 1b) [3]. The CR index was regarded as the shortest line between the radius and capitate (Figure 1b) [4].

Each observer was delivered 10 radiograms per day for 6 consecutive days. The same process was repeated two extra times, with one-week intervals. Accordingly, each observer evaluated each radiogram 3 times with a one-week interval between the evaluations. None of the volunteers were aware of the study's purposes.

Based on the calculations provided by the observers, the presence or absence of a carpal collapse was investigated. Accordingly, the carpal collapse was present if CHR was equal to <0.51 , RCHR was <1.52 , and CR distance was <0.92 .

The obtained data were analyzed in SPSS. Intra-class Correlation Coefficient (ICC); the two-way mixed model on the absolute agreement was used to evaluate the agreement of quantitative variables. Cohen's Kappa (k) coefficient was employed to assess the agreement between categorical variables. ICCs were interpreted according to established criteria for judgment [5]; high reliability (0.90-0.99), good reliability (0.80-0.89), fair reliability (0.70-0.79), and poor reliability (<0.69). To interpret K coefficients, the following scale by Landis and Koch [6] was applied: 0.81 to 1.0 regarded as almost perfect agreement, 0.61 to 0.80 considered as substantial agreement, 0.41 to 0.60 indicated moderate agreement, 0.21 to 0.40 reflected fair agreement, and 0.00 to 0.20 signified slight agreement.

3. Results

One radiogram was excluded from the study because of poor quality and degenerative joint disease at the base of the third metacarpal bone. The remaining 59 completed radiograms were analyzed by 3 observers. The results of evaluating the metacarpal length, carpal height, capitate length, and CR distance by 3 observers at 3 stages are demonstrated in Table 1.

The overall intra-observer reliability was equal to 0.891 for CHR, 0.792 for RCHR, and 0.942 for CR index. Accordingly, the intra-observer reliability was measured to be good for CHR, fair for RCHR, and high for CR index. Intra-observer reliability is provided in more detail in Table 2.

The mean inter-observer reliability was computed as 0.615 for CHR, 0.412 for RCHR, and 0.863 for CR index. Accordingly, the inter-observer reliability was computed to be poor for CHR and RCHR and good for CR index. Inter-observer reliability is listed in Table 3.

Overall K for determining carpal collapse by 3 methods was obtained as 0.683 for CHR, 0.549 for RCHR, and 0.776 for CR distance. According to K, substantial reliability was found for CHR and CR distance in determining the presence or absence of carpal collapse. Kappa values are demonstrated in Table 4.

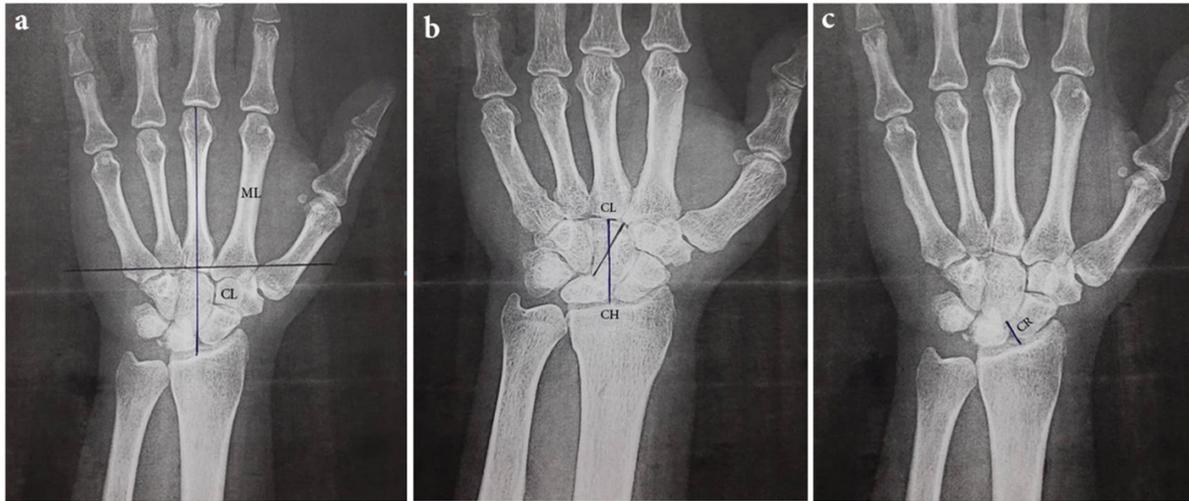


Figure 1. Evaluating carpal collapse thereby 3 different methods
(a) Carpal height ratio; (b) revised carpal height ratio; and (c) capitate-radius index.

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The most prominent agreement was observed between CHR and CR distance (ICC: 0.414). The least agreement was observed between the CHR and RCHR (ICC: 0.252) (Table 5).

4. Discussion

In this study, we assessed the reliability of 3 methods for assessing carpal collapse. According to our results, the CR index was the most reliable method in quantifying the carpal collapse; it presented intra-observer reliability of 0.942 (high reliability) and inter-observer reliability of 0.863 (good reliability). Additionally, the CR

distance signified substantial agreement in determining the presence or absence of carpal collapse (K: 0.776).

Youm index is the first described approach for carpal height measurement. It probably is the most commonly used approach. The major difficulty with CHR is the inability to visualize whole-length third metacarpal bone on numerous wrist X-rays [11]. Zdravkovic et al. explored wrist radiograms and concluded that the healthy Youm index ranges from 0.462 to 0.608, i.e., a wide range [9]. RCHR was introduced later by Nattrass and associates [12]. However, it was affected by the variations in the shape of the capitate, even between genders [13]. To address these limitations, the CR index was in-

Table 1. Mean±SD values for each assessor at 3 stages

Observer/Stage	Mean±SD			
	Metacarpal Length	Carpal Height	Capitate Length	CR Distance
Observer 1, stage 1	64.98±10.73	32.32±6.33	21.55±4.54	9.38±2.28
Observer 1, stage 2	65.00±10.11	32.74±5.92	21.72±4.17	9.27±2.19
Observer 1, stage 3	64.94±11.04	32.50±6.08	21.91±4.19	9.35±2.09
Observer 2, stage 1	65.08±11.43	32.11±6.10	20.40±3.94	7.91±2.11
Observer 2, stage 2	65.20±11.52	32.72±6.91	20.88±4.29	8.52±2.26
Observer 2, stage 3	65.28±11.40	32.81±6.66	20.93±4.37	8.62±2.29
Observer 3, stage 1	65.13±11.52	32.44±6.1	20.88±4.11	8.64±2.19
Observer 3, stage 2	64.9.3±11.36	33.76±5.99	21.02±4.14	8.96±2.23
Observer 3, stage 3	64.88±11.45	35.54±6.38	20.67±4.46	8.87±2.35

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Table 2. Intra-observer reliability of different methods by 3 observers

Rater	CHR	RCHR	CR index
Rater 1	0.946	0.887	0.938
Rater 2	0.828	0.689	0.941
Rater 3	0.901	0.802	0.947
Overall	0.891	0.792	0.942

CHR: Carpal Height Ratio, RCHR: Revised Carpal Height Ratio, CR: Capitate-Radius

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Table 3. Inter-observer reliability of various measurement methods at different time points

Stages	CHR	RCHR	CR Index
Stage 1	0.657	0.481	0.781
Stage 2	0.633	0.405	0.916
Stage 3	0.555	0.350	0.892
Mean	0.615	0.412	0.863

CHR: Carpal Height Ratio, RCHR: Revised Carpal Height Ratio, CR: Capitate-Radius

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troduced as the latest measure of carpal height [14]. Nevertheless, the superiority of the CR index over the earlier indices remains unclear.

Carpal collapse is a complicated concept. This is because no gold standard method is available for this measurement. The concept of healthy status (Mean±SD) may not be valid in numerous cases [7]. Comparison with the healthy side might be the best approach for this measurement. However, the normal value has to be defined for

every individual, which may present gender-wise differences [8]. These limitations highlight the necessity for developing improved methods for determining carpal collapse [10]. Until then, identifying the most appropriate available approach is necessary.

Natras et al. revealed the same reliability for CHR and RCHR [13]. Saied et al. demonstrated that the CHR method manifests better intra-observer reliability than the RCHR method; however, both approaches provided

Table 4. Kappa value for carpal collapse evaluated by 3 methods and 3 observers

Raters	CHR	RCHR	CR Index
Rater 1	0.741	0.621	0.777
Rater 2	0.622	0.483	0.772
Rater 3	0.686	0.543	0.781
Overall	0.683	0.549	0.776

CHR: Carpal Height Ratio; RCHR: Revised Carpal HeightR; CR: Capitate-Radius

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Table 5. Overall agreement of the 3 methods with each other in determining the carpal collapse

Methods	CHR	RCHR	CR Distance
CHR	–	0.252	0.414
RCHR	0.252	–	0.300
CR	0.414	0.300	–

CHR: Carpal Height Ratio; RCHR: Revised Carpal Height Ratio; CR: Capitate-Radius

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poor inter-observer reliability [15]. Only one study has evaluated the reliability of 3 different methods for carpal collapse evaluation. Agrawal et al. investigated the reliability of CHR, RCHR, and CR index in determining carpal collapse using 50 healthy wrist anteroposterior radiographs. According to their analysis, the inter and intra-observer reliability of the CR index was the highest between the 3 methods. They concluded that the CR index is the most accurate and reproducible approach to measure carpal collapse; it allows better staging of carpal disorders. They stated that this highest reliability could be attributed to using only one measurement compared to the CHR and RCHR, i.e., presented as a ratio [15]. Similar to the study of Agrawal et al., the CR index was introduced as the most reliable method to evaluate carpal collapse in the present study. Agrawal et al. disregarded evaluating the agreement level on the presence or absence of collapse. We assume that the crucial finding for reliability and consistency of carpal height measurement is the presence or absence of collapse. This is because the figure may change with slight alteration in observer's view.

Altogether, the CR index is more reliable than the CHR and RCHR method in determining the presence of absences of carpal collapse. However, our investigation was with limitations. The major limitation of the present study was using printed scans instead of radiograms, which made measurements easier. In CHR and RCH, this restriction may seem a less important concern; ratios are calculated rather than figures, a concept that was not proven.

5. Conclusion

Compared with the CHR and RCHR, the CR index is a more accurate method in quantifying carpal height, with a higher inter and intra-observer reliability. Additionally, the CR index was more reliable in determining the presence or absence of carpal collapse. These results signified the CR index as the optimal available method of choice for evaluating carpal collapse in future workouts.

Ethical Considerations

Compliance with ethical guidelines

The study was approved by the Review Board of our institute.

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Authors' contributions

Conception and design: Hooman Shariatzade; Data analysis: Alireza Saied; Mohsen Barkam; Peyman Hashemi; Writing – original draft: Masoud Hasanikhah; Reviewing the manuscript critically: Mohammadreza HeidariKho; Writing – review & editing: Mazyar Rajei.

Conflict of interest

The authors declared no conflicts of interest.

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