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The Carpal Height Ratio for The Trinidadian Population: What is Normal?

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Abstract

Aim: To determine the normal carpal height ratio for the Trinidadian population. **Design & method**: A retrospective review of wrist radiographs performed during the period January 2022 to June 2022 at San Fernando General Hospital was conducted. A total of 200 radiographs were independently reviewed by two blinded assessors utilizing the PACS system. The carpal height ratio (CHR) and revised carpal height (RCH) ratio was calculated using two methods. A p-value < 0.05 was assumed to be significant. **Results**: The radiographs reviewed consisted of 94 female and 106 male patients with an age range of 19 to 86 years. The mean CHR was 0.473 and the revised CHR 1.469. The ratio for carpal height as well as the revised CHR was observed to vary amongst the different age groups studied. The CHR and revised CHR for the population was observed to vary based on gender with gender significantly influencing the CHR value (p = 0.001). **Conclusions**: The CHR of the Trinidadian population as calculated by the data collected falls below the average CHR documented worldwide. However, the interpretation of this value is based on the baseline reference ratio for a population. Therefore, according to our average CHR for our population previous comparison of a CHR index to international figures would have led to erroneous interpretation of results. A decrease in CHR is indicative of carpal collapse. The comparison of CHR to the established normal CHR for the population is believed to allow for early detection of carpal collapse.

Keywords

Carpal Collapse, Carpal Height Ratio, Wrist Degenerative Disease, Wrist Pathology, Carpal Bone Disease

1. Introduction

Traumatic injuries of the hand are one of the most common complaints for which

individuals present to the Emergency room. The incidence of hand and wrist injuries carries a wide range from 57.4 to 700 per 100,000 [1] [2]. These injuries account for up to 30% of Emergency room visits yearly [1] [3]. The morbidity associated with hand trauma can be considerably high [4]. Patients usually recover gradually over several months with regards to their satisfaction with daily activities and quality of life. The long term sequelae of wrist and hand injury can be objectively assessed using the carpal height ratio (CHR). The CHR measures the degree of carpal collapse which results after injury to the hand. It is considered an important index in orthopaedics when managing individuals with hand and wrist pathologies.

This ratio has proven its usefulness in the evaluation of the level of severity as well as progression of disease. It also aids in the assessment of the surgical outcome for numerous wrist pathologies such as Kienbock's disease, rheumatoid arthritis, scaphoid fractures, and carpal ligamentous injuries. The ratio is obtained by the division of the carpal height by the length of the 3rd metacarpal. The expression of the carpal height as a ratio allows for the elimination of inaccuracies related to radiograph magnification, differences in radiographic technique as well as the size of the hand [5]. However, these radiological indices and ratios may vary with the race, gender and ethnicity. A standard reference database should be established for every population thereby allowing for comparison to determine whether a value is indeed a pathological value.

The revised CHR has been developed as an alternative index since it may not always be possible to measure the CHR. This may occur in patients whom the entire third metacarpal is not imaged or who have sustained injury to the third metacarpophalangeal joint. The revised CHR is measured by dividing carpal height by the length of the capitate. The well-defined anatomical margins of the capitate together with its limited involvement in disease process, makes it ideal for its use as a reference for the revised CHR. However, this method is not without its faults. The capitate shape is also not consistent amongst individuals and differs considerably between males and females [6].

In this study the CHR was evaluated by the assessment of simple plain radiography of non-pathological wrists. This allowed for the calculation of the normal CHR for the Trinidadian population as well as the determination regarding its variation with ethnicity and gender. A reference database was formulated to allow for an informed decision making process tailored to the Trinidadian population with regards to managing common wrist and hand injuries.

2. Methodology

A retrospective review of wrist radiographs performed during the period January 2022 to June 2022 at San Fernando General Hospital (SFGH) was conducted. All radiographs performed at the institution during the study period were accessed on the PACS system. A total of 1200 wrist radiographs were uploaded to the system during this period and available for review. All radiographs were reviewed by

a blinded observer and included for review by two blinded assessors provided that all parameters of the inclusion criteria were present. The inclusion criteria were as follows:

1) Standard posterior-anterior (PA) radiographs of wrist in a neutral position.
2) Patients aged 18 years and over.
3) Radiographs performed during the period January to June 2022.
4) The absence of previous or current wrist/hand trauma.
5) The absence of arthritic/degenerative disease of the wrist/hand.
6) The absence of congenital anomalies of the wrist/hand.

Radiographs were excluded if any of the following features were noted:

1) The presence of physis.
2) Patients less than 18 years old.
3) The presence of features suggestive of previous/current hand trauma such as fractures and soft tissue swelling.
4) The presence of arthritic/degenerative disease.
5) The presence of congenital anomalies.
6) Any radiograph which did not include both the wrist joint and hand.
7) Any radiograph without the wrist in a neutral position or limited image quality.

The PA radiographs were obtained with the upper limb at shoulder level with the upper arm abducted, the elbow flexed and the palm on the detector in a neutral position with fingers extended. A total of 200 radiographs were deemed acceptable for measurement by the observer and included in the study for analysis. The sample size was calculated with a power of 0.8 and a 0.95 significant level, resulting in 200 radiographs being required for review.

The radiographs were independently reviewed utilizing the PACS system. This was performed by two assessors who were blinded to the clinical details being assessed. All measurements were done in millimetres (mm) and handed over to another independent evaluator. The measurements that were performed are illustrated in Figure 1 and included the length of the third metacarpal (A), the carpal height (B) and the length of the capitate (C). The demographic data for each patient was obtained from their respective medical records as logged on the Cellma system for the respective date that the radiograph was performed.

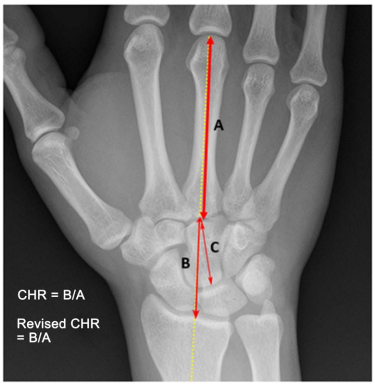

Figure 1. Annotated radiograph of measurements recorded.

The data obtained was stored using a Microsoft Excel Spreadsheet. The CHR and revised CHR was calculated using two methods. The Youm's method was used to determine CHR by dividing the carpal height value by that of the length of the 3rd metacarpal. Both measurements were taken in the long axis of the 3rd metacarpal. RCH ratio was determined by the Nattrass method. This value was calculated by the division of the carpal height, taken in the line of the long axis of the 3rd metacarpal, by the length of the capitate in its longest axis. Statistical analysis was done utilizing SPSS. The independent sample t-test and ANOVA testing were used to compare the mean values of the data collected. A p-value <0.05 was assumed to be significant.

3. Results

A total of 200 normal wrist radiographs were reviewed by two independent assessors. The radiographs assessed belonged to 94 female and 106 male patients with an age range of 19 to 86 years. Table 1 illustrates the mean CHR and revised CHR with standard deviations (SD) obtained by each assessor for the population studied. The mean CHR values for Observer 1 was found to be 0.473 ± 0.038 and for Observer 2 to be 0.482 ± 0.04. The mean revised CHR value was calculated at 1.469 ± 0.083 for Observer 1 and 1.467 ± 0.091 for Observer 2.

Table 1. Mean CHR and revised CHR values for each observer.

	Observer 1			Observer 2		
	Minimum	Maximum	Mean ± SD	Minimum	Maximum	Mean ± SD
CHR	0.381	0.574	0.473 ± 0.038	0.389	0.580	0.482 ± 0.040
Revised CHR	1.270	1.747	1.469 ± 0.083	1.255	1.771	1.467 ± 0.091

The ratio for carpal height as well as the revised CHR was observed to vary amongst the different age groups studied. Table 2 illustrates the varied values for each group obtained by each assessor.

Table 2. Age group distribution of CHR and revised CHR.

	<40 years	40 - 65 years	>65 years
CHR Observer 1	0.480	0.466	0.476
CHR Observer 2	0.489	0.473	0.494
Revised CHR Observer 1	1.474	1.464	1.475
Revised CHR Observer 2	1.460	1.457	1.505

Table 3 shows the variation of carpal height ratio and revised CHR amongst the various ethnic groups as recorded by each assessor. Statistical analysis however, found that the ethnic variation amongst the study population was not significant with regards to the difference observed amongst the CHR and revised CHR values (p = 0.27).

Table 3. Distribution of CHR and revised CHR amongst the various ethnic groups.

Ethnic Group (N)	Observer 1		Observer 2	
	CHR	Revised CHR	CHR	Revised CHR
East Indian (82)	0.474	1.471	0.482	1.462
African (74)	0.470	1.469	0.482	1.461
Mixed (24)	0.483	1.471	0.489	1.482
Chinese (10)	0.462	1.478	0.482	1.485
Caucasian (8)	0.477	1.430	0.471	1.474
Hispanic (2)	0.436	1.513	0.451	1.528

The CHR and revised CHR for the population was observed to vary based on gender with gender significantly influencing the CHR value ($p = 0.001$). The revised CHR values, when analysed against gender, showed no statistically significant variation ($p = 0.8$). Table 4 illustrates the mean values obtained by each assessor with regards to the two gender subsets.

Table 4. Relationship of CHR and revised CHR to gender.

	Male	Female	p-value
CHR	0.486 ± 0.045	0.462 ± 0.050	0.001
Revised CHR	1.47 ± 0.085	1.468 ± 0.081	0.8

4. Discussion

Youm *et al.* first introduced the concept of carpal height ratio (CHR) in 1978 [7]. They established the normal CHR as 0.54 ± 0.03 and proposed that a decrease in CHR be used as an indicator of carpal bone disease [7] [8]. However, sometimes the third metacarpal is not visualized fully on the radiographs due to technical problems such as the coning down effect of the radiographic beam. Therefore, the concept of the revised CHR was proposed by Nattrass *et al.* [6]. There have been several reports regarding the normal CHR and revised CHR for various populations worldwide. The average CHR in different studies, amongst various ethnic groups ranges from 0.51 to 0.54 with the mean CHR in our study being 0.47 [9]-[11]. The average revised CHR in the literature ranged from 1.4 to 1.57 with that of our study being 1.5 [12] [13].

The CHR of the Trinidadian population as calculated by the data collected falls below the average CHR documented worldwide. However, the interpretation of this value should be based on the baseline reference ratio for that respective patient population. Therefore, according to our average CHR for our population previous comparison of a CHR index to international figures would have led to erroneous interpretation of results. This ratio is utilized as a standardized method of calculating carpal height with a decrease in CHR being indicative of carpal collapse, which is commonly found in many wrist pathologies. The comparison of

CHR to the established normal CHR for the population is believed to allow for early detection of carpal collapse while preventing the inappropriate treatment of patients who may have a CHR which varies from the international values but may be well within range for that individual population subset.

It is also important to analyse the "rounding-up error" when interpreting measurements. The "naked-eye measurements" are only possible with rounding-up to 0.5 mm when using a millimeter scale therefore giving results recorded at 0.5 mm precision. The overall error when two distances are measured to obtain one result is determined by the product of the "rounding up error" for the two measurements. Therefore, there may be an error of ±0.25 mm for each measured distance. This study attempted to decrease this error factor by utilizing 2 independent, blinded assessors to obtain measurements.

In our study, CHR was found to have a statistically significant variation between the two gender sub groups. However, the revised CHR demonstrated a difference in value but was not found to be statistically significant for evaluation. This gender-specific variation was also seen in the population of Taiwan region by Wang *et al.* in 2010 with significantly higher values in their male population as was demonstrated in our study [5]. The recommendation by Wang *et al.* was the use of a gender-specific CHR to avoid underdiagnosing subtle wrist disorders in men or over diagnosing carpal abnormality in women [5]. The authors believe that this in an important factor to consider for our population in light of the high numbers of working class individuals presenting to the Emergency room and outpatient clinics with wrist symptomatology.

Although various ethnic groups have been studied and have established baseline CHR, a comparison between groups to determine the significance of the variations noted has not been documented in the literature. The variation of CHR according to ethnic origin for our population revealed a difference in the average ratios amongst the different ethnic groups. However, this difference when analysed was not found to be statistically significant for our population. This can be attributed to the small numbers in each ethnic subgroup.

The interpretation of the CHR index is subjective since its comparison is generally made to that of a previously studied population. However, our study has shown that this "normal range" varies amongst different population subsets. In patients with unilateral disease, a more accurate comparison can be obtained by comparing the pathological radiograph with the values obtained from the opposite wrist radiograph.

5. Conclusion

The average CHR for the Trinidadian population is 0.47 with an average revised CHR of 1.5. These values have been shown to vary based on patient gender but are independent of ethnicity. The authors propose that these values be used as the normal values for comparison when interpreting CHR values for the Trinidadian population. Patients with unilateral disease and a normal contralateral wrist

radiograph should have the interpretation of their CHR made in comparison to their normal (contralateral) wrist values.

6. Limitations

Like all other studies, our study had some limitations. The risk of inaccurate measuring due to operator related technique for performing the radiographs was one such limitation. The sampling technique was purposive involving only apparent normal radiograph from a single center and therefore not a random selection of the entire population of Trinidad.

Conflicts of Interest

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

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