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KINEMATIC RADIOGRAPHIC MEASUREMENTS OF THE WRIST IN THE HEALTHY POPULATION IN THE REPUBLIC OF MACEDONIA

Foteva M., Poposka A.

University for Orthopaedic Surgery Clinic, Medical Faculty, Skopje, R. Macedonia

Abstract: Many diseases of the wrist can be recognized by radiographic changes and quantified by radiographic measurements. The kinematic radiographic measurements are the basis for kinematic studies of the wrist as well as a diagnostic, prognostic and follow- up tool for many conditions of the wrist. We undertook this study to identify the normal variations in the longitudinal and transverse dimensions of the wrist, and measure several indices on posteroanterior roentgenograms of the wrists of the healthy population in the Republic of Macedonia. There were 100 healthy subjects (47 men and 53 women), 41 left and 59 right hands. The mean age of the subjects was 42 years ± 12.42 (range 20 to 60 years). Measurements were made of the third metacarpal, the carpal height, the length of the capitate and the carpal- ulnar distance. The indices, expressed as ratios, included the carpal height ratios (we used two methods – CHR by Youm and Revised CHR as described by Natrass) and the Carpal-Ulnar Distance Ratio. The results we obtained are similar to those we find in the literature (CHR – 0.53 ± 0.01; RCHR – 1.56 ± 0.02; Carpal-Ulnar Distance Ratio – 0.30 ± 0.01). This study shows that these methods are reproducible and the values represent normal reference values that can be used in further kinematic studies of the wrist in our population. Also, these measurements can be used in determining the degree of kinematic dysfunction present in people with wrist abnormalities, and in evaluation of the kinematic effectiveness of real and hypothetical treatment modalities, thus making them exceptionally valuable for the orthopaedic surgeons.

Key words: wrist, kinematics, carpal bones radiography, reference values.

Introduction

The hand and wrist have been the subject of medical imaging since the first radiograph, an image of his wife's hand, produced and published in 1896 by W C Röntgen. The clinical-radiological interest in the wrist is due to its extreme anatomical and biomechanical complexity (De Filippo, 2006). It is remarkable to think that as many as ten skeletal segments together with numerous ligamentous and tendinous structures interact and move so harmoniously in such a small space. Despite the development of numerous new and sophisticated imaging techniques, the humble radiograph still remains the single most important imaging modality for the hand and wrist (Taleisnik, 1985). A patient with a painful, dysfunctional or deformed carpus presents as a true diagnostic and therapeutic challenge. Many diseases of the wrist can be recognized by radiographic changes and quantified by radiographic measurements (Stahelin, 1989). Kinematic radiographic measurements were first introduced in 1978 by Youm *et al*. and included: carpal height, carpal height ratio and carpal-ulnar distance. In the next decades, more measurements, indices and ratios were described, so the kinematic radiographic measurements became the basis for kinematic studies of the wrist as well as a diagnostic, prognostic and follow-up tool for many conditions of the wrist (arthritic changes, posttraumatic disorders, rheumatoid arthritis, etc.)

These measurements are still not in use in our country and so far, no attempt has been made to introduce them in clinical practice. In order to use them in pathologic conditions of the wrist, first we have to standardize the kinematic radiological measurements in the healthy population and obtain normal radiographic reference values. We undertook this study to identify the normal variations in the longitudinal and transverse dimensions of the wrist, and measure several indices on posteroanterior roentgenograms of the wrists of the healthy population in the Republic of Macedonia.

Materials and Methods

We made measurements on the posteroanterior roentgenograms of the wrists and hands of 100 normal subjects that were divided into groups according to sex and age (twenty to forty years and 41 to sixty years). Individuals who had a history of previous operative interventions, fractures, congenital anomalies, or signs and symptoms suggestive of disorder of the upper limb were excluded from the study. Posteroanterior roentgenograms were made of the wrist and hand, with the wrist and hand in a neutral position, the elbow at 90 degrees of flexion and the shoulder at 90 degrees of abduction. The X-ray tube was aligned vertically to the radial styloid. All of the roentgenograms were

digitalized and enlarged to allow for precise identification of the key anatomical landmarks. Measurements were made in millimetres of the third metacarpal, the carpal height, the length of the capitate and the carpal-ulnar distance. The indices, expressed as ratios, included the carpal height ratios (we used two methods-CHR as described by Youm and Revised CHR as described by Natrass) and the carpal-ulnar distance ratio.

The length of the third metacarpal was measured along the longitudinal axis from the distal metacarpal to the subchondral margin of the proximal metacarpal (Fig. 1). The length of the capitate is the measurement of the longest distance from the distal distinct line (the subchondral margin of the capitate at the capitate-third metacarpal junction) to the proximal aspect of the capitate (Fig. 2).

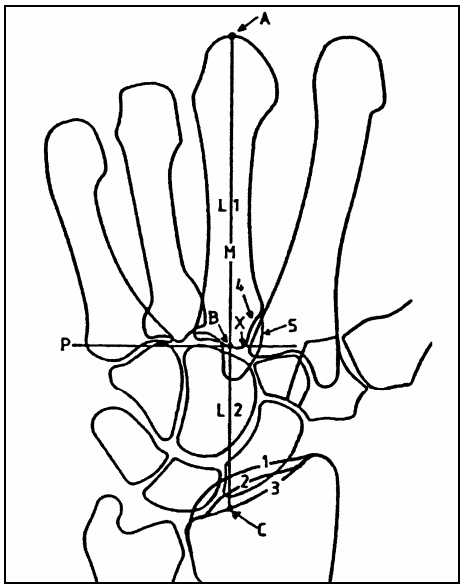


Figure 1 – Measurement of the length of third metacarpal (L1), carpal height (L2) and carpal height ratio (L1/ L2)

Слика 1 – Мерење на должината на третата мекарпална коска (L1), карпална височина (L2) и однос на карпална височина (L1/L2)

The carpal height, as defined by Youm, was measured as the distance between the base of the third metacarpal and the distal articular surface of the radius, along the extension of the longitudinal axis of the third metacarpal (Fig. 1).

The carpal height ratio (CHR) is determined by division of the carpal height by the length of the third metacarpal – 11/12 (Fig. 1), as described by Youm. The revised carpal height ratio (RCHR) is determined by division of the carpal height by the length of the capitate, as described by Natrass (Fig. 2).

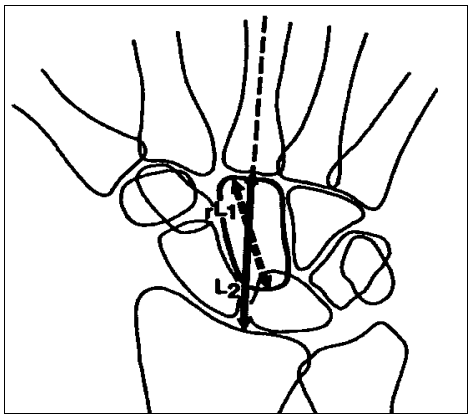


Figure 2 – Measurement of the RCHR: rL1 – length of capitate, L2 – Carpal height; RCHR = rL1/L2

Слика 2 – Мерење на RCHR (ревидиран однос на карпална височина): rL1 – должина на os capitatum, Л2 – карпална височина; RCHR = rL1/L2

The carpal-ulnar distance is defined as the perpendicular distance from the centre of rotation for radial-ulnar deviation of the wrist (the head of the capitate) to the longitudinal axis of the ulna projected distally when measured on a posteroanterior roentgenogram (Fig. 3). The carpal-ulnar ratio is determined when this distance is subtracted from the length of the third metacarpal (11/13).

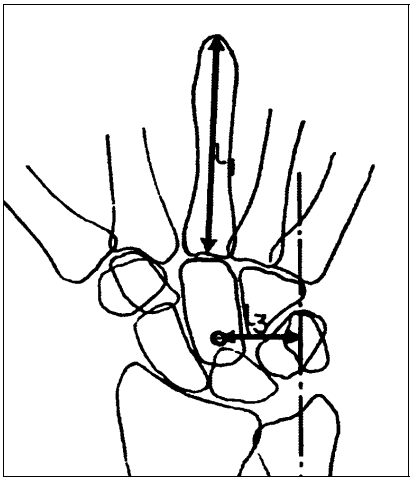


Figure 3 – Measurement of carpal-ulnar distance ratio L1/L3: L: length of third metacarpal, L3: Carpal-ulnar distance

Слика 3 – Мерење на однос на карпално-улнарна дистанца L1/L3, L1 – должина на третта метакарпална коска, L3 – карпално-улнарна дистанца

For the Statistical Analysis we used descriptive tests (mean, standard deviation), t-test for independent samples and the Pearson coefficient for parameter correlation.

Results

The mean age of the patients was 42 years ± 12. 42 (range 20 to 60 years). There were 47 men and 53 women. We examined the radiographs of 41 left and 59 right hands from different patients. Figures 4 and 5 are two radiographs showing measurement of the CHR, RCHR and Carpal-Ulnar Distance Ratio on subjects from our study group. In Figure 5 note the missing distal part of the third metacarpal which would not allow measurement of the CHR, but the RCHR can be measured.

Figure 4 – Measurement of CHR and Carpal-ulnar distance ratio in one of the radiographs in our study
Слика 4 – Мерење на однос на карпална височина и однос на карпално-улнарна дистанца на рентгенографија од нашата студија

Figure 5 – Measurement of RCHR in one of the radiographs in our study
Слика 5 – Мерење на ревидиран однос на карпална височина на рентгенографија од нашата студија

The results of the study group (mean, minimum, maximum and std. deviation) for the measured variables are given in Table 1. The CHR (Carpal Height Ratio) is 0.53 ± 0.01, RCHR (Revised Carpal Height Ratio) is 1.56 ± 0.02 and the Carpal-Ulnar Distance Ratio is 0.30 ± 0.01.

Table 1 – Табела 1

Descriptive statistics results for the measured variables
Дескриптивно-статистички резултати за измерените варијабли

Variable	Mean	Minimum	Maximum	Std. dev
Carpal height	32,77	28,00	39,00	2,984
CHR	0,53	0,51	0,57	0,015
RCHR	1,56	1,50	1,61	0,02
Carpal-ulnar distance ratio	0,30	0,28	0,32	0,01

Tables 2, 3 and 4 show the results for tested differences between the parameters of two age, sex and hand groups.

Table 2 – Табела 2

Tested differences for the parameters between the two age groups
Тестирани разлики за параметрите меѓу две возрасни групи

Variable **age**	Mean 1 (20–40)	Mean 2 (41–60)	t-value	p	Std. dev. 1 (20–40)	Std. dev. 2 (41–60)
Carpal height	33,0	32,6	0,65	0,51	2,81	3,11
CHR	0,54	0,53	1,08	0,27	0,01	0,01
RCHR	1,56	1,56	0,84	0,39	0,02	0,02
Carpal-ulnar distance ratio	0,29	0,30	-1,28	0,20	0,01	0,01

Table 3 – Табела 3

Tested differences for the parameters between the two sex groups
Тестирани разлики за параметрите меѓу двете полови групи

Variable **sex**	Mean 1 male	Mean 2 female	t-value	p	Std. dev. 1 (male)	Std. dev. 2 (female)
Carpal height	32,7	32,7	-0,07	0,93	2,91	3,07
CHR	0,53	0,53	-0,20	0,83	0,01	0,01
RCHR	1,56	1,55	1,04	0,29	0,01	0,02
Carpal-ulnar distance ratio	0,30	0,30	0,14	0,88	0,01	0,01

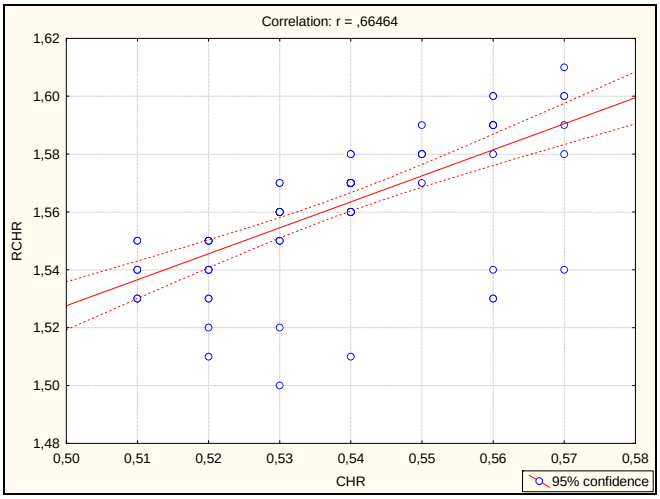
Table 4 – Табела 4

Tested differences for the parameters between the two hand groups
Тестирани разлики за параметрите меѓу двете групи на шепи

Variable **hand**	Mean 1 left	Mean 2 right	t-value	p	Std. dev. 1 left	Std. dev. 2 right
Carpal height	33,7	32,1	2,7	0,00	2,99	2,82
CHR	0,53	0,53	-1,01	0,31	0,01	0,01
RCHR	1,55	1,56	-1,84	0,06	0,02	0,01
Carpal-ulnar distance ratio	0,30	0,29	1,58	0,11	0,00	0,01

There was no statistically significant difference between the two age, sex and hand groups regarding the measurements. This shows that the same reference values can be used for both sexes and both hands for the adult population in the range 20–60 years.

We used the Pearson coefficient of linear correlation test to show the correlation between the values for the CHR and RCHR (Graph 1). This test showed marked correlations are significant at $p < 0.05$ for the CHR and RCHR. This means that both CHR and RCHR can be used with the same accuracy.



Graph 1 – r – Pearson coefficient of linear correlation between CHR and RCHR = 0. 7 at p < 0.05
Графикон 1 – р – Пеарсонов коефициенӣ на линеарна корелација йомеѓу CHR и RCHR = 0.7, p < 0.05

Discussion

The Carpal Height Ratio (CHR) was first described by Youm *et al*., who reported a normal value of 0.54 ± 0.03. Stahelin reported a value of 0.54 ± 0.04 and Schiund – 0.53. Our Carpal Height Ratio in normal healthy subjects is 0.53 ± 0.01, which is comparable and similar to all of the above studies. However, two common problems have been encountered with the use of this method: First – often the distal aspect of the third metacarpal is not included on routine posteroanterior radiographs of the wrist, and second – when the third metacarpophalangeal joint has been affected by destructive joint disease, the length of the third metacarpal is difficult to measure (Natrass, 1994). To overcome this problem, an alternative method was devised by Natrass *et al*. to define the Carpal Height Ratio with the use of the length of the capitate instead of the third metacarpal. This so-called Revised Carpal Height Ratio (RCHR) in our study is 1.56 ± 0.02 which was similar to the value reported by Natrass – 1.57 ± 0.05 and other studies.

Carpal collapse is another term introduced by Youm *et al*., which is defined as a decrease in the CHR during progressive stages of many diseases that involve the wrist. The importance of the CHR and RCHR is in its use in pathologic conditions of the wrist which lead to carpal collapse (Bouman, 1994; Ucan, 2006).

Carpal-ulnar distance ratio can be used clinically to obtain a quantitative expression of ulnar shift of the carpus in pathological states of the wrist, the so-called carpal translation. It is considered especially useful for evaluation of patients with rheumatoid arthritis. In our series of patients the carpal-ulnar distance ratio is 0.30 ± 0.01. This value is similar to the results of all the studies for normal healthy subjects.

We also reviewed studies that found differences between the two sex or age groups for the measurements in different populations – Chinese, Egyptian, Mexican (Wang YC, 2010; Mohammed Ali MH., 2009; Torres-Gonzalez R., 2006). However, in our study groups we found no significant difference between the two age groups, between the left and right hand and between men and women. We believe that these ethnographic differences are not present in our population and are therefore insignificant.

Conclusion

The objective of our study was to obtain normal radiographic reference values for the kinematic radiographic measurements of the wrist in the Republic of Macedonia. Our results for the carpal height, carpal height ratio, revised carpal height ratio and carpal-ulnar distance and ratio are identical with those found in the literature. The methods we used are shown to be reproducible and can be used in further kinematic studies and in determining the degree of kinematic dysfunction present in people with wrist abnormalities. By using ratios, differences in hand size and roentgenographic magnification are eliminated as variables. The technique was easy to learn and use.

We expect to find them especially useful in evaluation of the kinematic effectiveness of real and hypothetical treatment modalities, thus making them exceptionally valuable for orthopaedic surgeons.

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Резиме

КИНЕМАТСКИ РАДИОГРАФСКИ МЕРЕЊА НА КИТКАТА КАЈ ЗДРАВА ПОПУЛАЦИЈА ВО РЕПУБЛИКА МАКЕДОНИЈА

Фотева М., Попоска А.

Универзитетска клиника за ортопедски болести, Медицински факултет, Скопје, Р. Македонија

Апстракт: Многу болести на китката може да се откријат преку радиографски промени и да се квантифицираат со радиографски мерења. Кинематските радиографски мерења се основа за кинематски студии, но

исто така и алат за дијагноза, прогноза и следење при многу состојби на китката. Ја преземавме оваа студија со цел да ги идентификуваме нормалните варијации во лонгитудиналните и трансверзалните димензии на китката и да измериме неколку индикатори на постероантериорни рентгенограми на китка кај здрава популација во Р. Македонија. Учествуваа 100 здрави субјекти (47 мажи и 53 жени), 41 леви и 59 десни шепи. Средната возраст на субјектите изнесуваше 42 години ± 12,42 (опсег – 20–60 години). Ги користевме следните мерења: должина на третата метакарпална коска, карпална височина, должина на os capitatum и карпално-улнарна дистанца. Индикаторите, кои ги изразивме како однос, ги вклучуваа: однос на карпална височина – Carpal Height Ratio (употребивме две методи – CHR опишан од Youm и ревидиран CHR според Natrass) и однос на карпално-улнарна дистанца – Carpal-ulnar Distance Ratio. Добиените резултати наликуваат на оние кои ги наоѓаме во литературата (CHR – 0,53 ± 0,01; RCHR – 1,56 ± 0,02; Carpal-ulnar Distance Ratio – 0,30 ± 0,01). Оваа студија покажува дека методите може да се репродуцераат и добиените вредности претставуваат нормални радиографски референтни вредности кои можат да се користат во понатамошни кинематски студии на китката кај нашата популација. Исто така, овие мерки може да се користат за одредување на степенот на карпална дисфункционалност кај луѓе со абнормалности на китката, како и за евалуација на кинематската ефективност на вистински и хипотетски тераписки модалитети. Со тоа тие се особено корисни за ортопедските хирурзи.

Клучни зборови: китка, кинематика, радиографија на карпални коски, референтни вредности.

Corresponding Author:

D-r Marta Foteva, M-r Sci
University Orthopedic Surgery Clinic,
Skopje, R. Macedonia
tel.: +389 70 221 581

E-mail: martafoteva@hotmail.com