Distribution of primary osteoarthritis in the ulnar aspect of the wrist and the factors that are correlated with ulnar wrist osteoarthritis: a cross-sectional study

Takeshi Katayama, MD[1]; Hiroshi Ono, MD[1]; Daisuke Suzuki, MD[1]; Manabu Akahane, MD[2]; Shohei Omokawa, MD[3]; Yasuhito Tanaka, MD[3]

[1]Department of Orthopaedic Surgery, Kokuho Central Hospital
[2]Department of Public Health, Health Management and Policy, Nara Medical University
[3]Department of Orthopaedic Surgery, Nara Medical University

Corresponding author:
Takeshi Katayama, MD
Department of Orthopaedic Surgery, Kokuho Central Hospital, 404-1 Miyako, Tawaramoto, Nara 636-0302, Japan
Tel: +81-744-32–8800
Fax: +81-744-32-8811
E-mail: takeshi.k11@k4.dion.ne.jp

Disclaimers: None
Acknowledgments: None

Abstract

Objective: The purpose of this cross-sectional study was to identify the distribution of primary osteoarthritis (OA) in the ulnar aspect of the wrist, and analyze the factors correlated with OA at this site.

Materials and methods: A total of 1128 cases of skeletally mature Japanese patients were collected over a three-year period. We analyzed the posteroanterior and lateral wrist radiographs of these patients for the presence of primary OA in the ulnar aspect of the wrist, including the distal radioulnar (DRUJ), radiolunate, ulnolunate, lunotriquetral, triquetrohamate, lunohamate and lunocapitate joints. All joints were examined for the frequency of primary OA. A multivariate logistic regression was used to investigate the factors correlated with the presence of degenerative arthritis in the ulnar aspect of the wrist joint.

Results: Primary OA of the ulnar wrist was identified in 145 (12.8 %) of 1128 cases. Degenerative changes were most frequently identified in the DRUJ (12.3 %), followed by the ulnolunate joint (8.1 %). Variations in radial inclination (RI), carpal height ratio (CHR), and ulnar variance (UV) correlated with OA of the ulnar aspect of the wrist, with variations in UV showing the highest correlation.

Conclusion: Primary OA of the ulnar wrist was most frequent in the DRUJ and second-most in the ulnolunate joint. UV was the most correlated with OA in the ulnar aspect of the wrist.

Key words: osteoarthritis, ulnar aspect, wrist, radiography

Introduction

Ulnar-sided wrist pain is a common clinical problem and presents a diagnostic challenge for radiologists and hand surgeons, because of the complex anatomical structures in this region [1, 2]. Disorders of the ulnar wrist are complicated, and there are a number of degenerative conditions that can lead to pain and disability. These conditions often consist of multifactorial etiologies, making it difficult to implement appropriate treatment strategies [3]. However the main causes of ulnar-sided wrist disorders include triangular fibrocartilage complex (TFCC) tears, lunotriquetral ligament instability, extensor carpi ulnaris tendonitis and ulnocarpal impaction syndrome [2, 4]. Palmer classified degenerative TFCC disorder into five grades, and found that perforations of the TFCC result in ulnocarpal abutment and cartilage erosion, eventually leading to ulnocarpal arthritis [5]. Distal radioulnar joint (DRUJ) instability associated with radioulnar ligament tear may accelerate cartilage wear of the joint [6]. However the etiology of non-traumatic osteoarthritis (OA) in the ulnar aspect of the wrist remains unknown. Frequency and pathogenesis of radiocarpal and radial midcarpal OA have been extensively investigated [7, 8], whereas there has been no research on the distribution of OA or the importance of the alignment change of the wrist and carpal bones in the ulnar aspect of the wrist with OA.

This cross-sectional study sought to identify the distribution of primary OA in the ulnar aspect of the wrist, and to analyze the factors that are correlated with the presence of OA at this site. We hypothesized that OA in the ulnar aspect of the wrist would be most frequently observed in the DRUJ and that OA of the ulnar aspect of the wrist would correlate with the alignment and configuration of the wrist and carpal bones.

Materials and Methods

This was a retrospective radiographic study using posteroanterior (PA) and lateral wrist radiographs. This study was approved by our hospital review board. We included all skeletally mature Japanese patients with closed epiphyseal plates who visited our general orthopaedic practice from January 2008 to December 2010 with wrist symptoms. Patients presented to the clinic with trauma (e.g., contusion, sprain, tendon or ligament injury, nerve injury), inflammation (e.g., cellulitis, carpal tunnel syndrome, stenosing tenosynovitis, pseudo gout, purulent arthritis), OA (e.g., ulnocarpal abutment syndrome), or tumor (e.g., ganglion, lipoma, atheroma). Patients were excluded if they presented with fractures of the radius, ulna, or carpal bones, or secondary OA of the wrist due to: (1) fractures or malunions of the radius, ulna, carpal bones, and metacarpal bones; (2) rheumatoid arthritis, dialysis-related arthritis, or other systemic arthritic conditions; (3) avascular necrosis of the carpus; and (4) congenital deformities. All patients were diagnosed based on both the radiographic findings and clinical records to avoid inappropriate clinical diagnosis.

Standard PA radiographs [9] of the wrist were taken with the wrist in a neutral position between both flexion-extension and radial-ulnar deviation: the forearm was in a neutral position of pronation-supination, with the elbow bent in 90 degrees of flexion, and the shoulder held in 90 degrees of abduction. Standard PA radiographs of the wrist were indicated when the ulnar styloid process localized in the lateral border of the ulnar head. Standard lateral radiographs [10] of the wrist were taken with the wrist and forearm in a neutral position, the elbow in 90 degrees of flexion, and the shoulder in 0 degree of abduction. Standard lateral radiographs of the wrist were indicated when the pisiform localized in between the volar margins of the scaphoid tubercle and the capitate. Radiographic exams were excluded if they were of insufficient quality for evaluation or if the examination did not include both of these two views.

To clarify the distribution of primary OA in the ulnar aspect of the wrist using PA and lateral wrist radiographs, the ulnar wrist joints were defined as following joints: DRUJ, radiolunate, ulnolunate, lunotriquetral, triquetrohamate, lunohamate and lunocapitate joints (Figure 1). The PA radiographic criteria for OA of the wrist joint were defined as the presence of one or more of the following: joint space narrowing (where the shortest distance between each bone must be less than 1 mm), osteophytes (identified as bony excrescences at joint margins), subchondral sclerosis (identified as sclerotic changes to the cortical and trabecular bone in contact with the cartilage) or subchondral cysts (identified as subchondral bone lucency within areas of subchondral sclerosis) [8, 11, 12]. The lateral radiographic criteria were defined as the presence of osteophytes in the volar or dorsal side of the DRUJ. All joints in the distal radioulnar, ulnocarpal and ulnar midcarpal areas were examined for the presence or absence of these features of OA, as outlined in Figure 1. The joint was defined as having a positive osteoarthritic change, when one or more features of OA were recognized in each joint. If no features were observed, the joint was defined as negative for osteoarthritic change. To identify the prevalence of joints with primary OA in the ulnar aspect of the wrist, all of the enrolled PA and lateral wrist radiographs were examined. The frequency of an osteoarthritic joint was identified.

Next, standard PA and lateral radiographs of the wrist were assessed to identify the factors that are correlated with OA in the ulnar aspect of the wrist. Based on clinical records, we selected a control group of patients with no OA in the ulnar aspect of the wrist from the original cohort of 1128 cases, to act as an age- and gender-matched control for the patients with OA. The age of control patient was within 1 year of age (older or younger) of the OA group (Table 1). Radial inclination (RI) [13], carpal height ratio (CHR) [14], and ulnar variance (UV) [9] were measured on standard PA radiographs of the wrist. The ulnar variance was measured by the method of perpendiculars [9]: a line was drawn perpendicular to the longitudinal axis of the radius and through the distal margin of the volar edge of the sigmoid notch of the radius. The distance was measured between this line and the distal cortical rim of the ulna to determine the UV (Figure 2). A positive UV was defined as more than 2 mm. Volar tilt (VT) [15], radiolunate angle (RLA) [16], and radioscaphoid angle (RSA) [16] were measured on standard lateral radiographs of the wrist.

Two independent observers (T.K; board-certified orthopedic surgeon, and H.O; board-certified hand surgeon) reviewed radiographs for the groups of patients with and without OA. One observer (T.K.) performed a second measurement 1 month after the first measurement.

All radiographs were acquired using digital radiography and stored using a Syngo Imaging XS-VA60B system (Siemens, Erlangen, Germany). The measurements of the radiographs were made using a software tool of the Syngo Imaging XS-VA60B system.

Statistical analysis

Factors were analyzed by the Pearson correlation coefficient for eight parameters (gender, age, RI, UV, CHR, VT, RLA, and RSA) and the presence or absence of OA at the ulnar aspect of the wrist joint. A multivariate logistic regression analysis was then performed. The object variable was defined as the presence or absence of OA at the ulnar aspect of the wrist joint. The explanatory variables were parameters that confirmed a statistically significant correlation by the Pearson correlation analysis. The odds ratio of each explanatory variable was calculated with a 95%

confidence interval (CI). Statistical results were analyzed with the significance level set at $P < 0.05$.

The inter- and intra-observer reliability of measurements for each radiographic parameter was calculated using the intraclass correlation coefficient (ICC). The reliability of a decision for or against the presence of OA in each joint was assessed using the kappa values. The interpretation of the ICC and kappa values was based on the criteria proposed by Landis and Koch [17]. ICC and kappa values of 0.00 to 0.20 represented slight agreement; 0.21 to 0.40 represented fair agreement; 0.41 to 0.60 represented moderate agreement; 0.61 to 0.80 represented substantial agreement; and over 0.80 represented almost perfect agreement.

Results

Of the patients visiting the clinic, 1408 patients (609 men and 799 women; mean age, 53.8 years; range, 19-100 years) met the inclusion criteria, with 280 patients excluded (121 men and 159 women; mean age, 52.1 years; range, 19-95 years). Overall, we obtained relevant patient and radiographic information from 1128 consecutive patients (488 men and 640 women; mean age, 54.2 years; range, 19-100 years). Of these 1128 patients, 145 (12.8 %) cases (51 men and 94 women; mean age, 67.6 years; range, 30-100 years) presented with primary OA in the ulnar aspect of the wrist on the PA radiographs. The frequency of positive UV was found in 59 of the 145 cases with OA. The most frequent area to involve degenerative arthritic changes was the DRUJ, which was found in 139 of the 145 patients, which comprised 12.3% of the total 1128 cases. Fifty seven of 139 cases with OA of the DRUJ had a positive UV. In the 145 cases with OA of the ulnar aspect of the wrist, 2 of 6 cases without OA of the DRUJ had positive UV. The second most-frequent area with OA was the ulnolunate joint, which was observed in 91 (8.1 %) of the 1128 cases. In order of descending prevalence, 53 cases (4.7 %) demonstrated degenerative changes in the lunocapitate joint; 46 cases (4.1 %) in the radiolunate joint; 40 cases (3.5 %) in the triquetrohamate joint; 38 cases (3.3 %) in the lunohamate joint; and 14 cases (1.2 %) in the lunotriquetral joint (Figure 3). On the lateral radiographs, osteophytes were observed in two cases, which were seen in the sigmoid notch of the radius on both PA and lateral radiographs.

The age- and gender-matched control group comprised 145 cases (52 men and 93 women; mean age, 67.3 years; range, 39-85 years) from the original cohort of 1128 consecutive cases that did not have OA of the wrist joint; the difference between patients with and without OA was not statistically significant with respect to age (P=0.932) or gender (P=0.901) using independent t-tests. The frequency of positive UV was found in 33 of 145 control cases. We then used these two groups to determine which factors were correlated with OA in the ulnar aspect of the wrist. Table 1 shows the characteristics of each variable between the two groups. Using these variables, a correlative analysis was conducted, revealing that the presence of OA at the ulnar aspect of the wrist joint was significantly correlated with RI, UV, CHR, and RLA (Table 2). The multivariate logistic regression analysis revealed that RI, UV, and CHR were statistically correlated with OA of the ulnar aspect of the wrist joint (Table 3). Among these variables, UV had the highest significant correlation with OA of the ulnar aspect of the wrist joint ($P<0.001$).

The ICC and kappa values for inter- and intra-observer agreement were almost perfect or in substantial agreement (Table 4), suggesting that the measurement methods were reproducible.

Discussion

In this study, we analyzed the distribution of primary OA in the ulnar aspect of the wrist and sought to determine the factors that correlate with ulnar wrist OA, with reference to the alignment and configuration of the wrist and carpal bones.

From a cohort of 1128 consecutive cases, we identified that 12.8% (145 cases) of patients presenting to our institute showed degenerative osteoarthritic changes in the ulnar aspect of the wrist using standard PA radiographs. We observed osteophytes on lateral radiographs in two cases. In these two cases, osteophytes were seen in sigmoid notch of the radius on both PA and lateral radiographs. As the carpal bones overlapped on lateral radiographs, we could not judge the features of OA, except to determine that one was located in the area of the sigmoid notch of the radius. Thus, we determined the presence of osteophytes for the definition of OA using only PA views. This percentage (12.8 %) of ulnar wrist OA is lower than that reported by Yamazaki et al. [18], where asymptomatic OA of the DRUJ was identified in 26 % (34 out of 130 wrists) from 65 normal volunteers. The difference between results could be attributed to a different criteria of inclusion. We included the patients with wrist symptoms; however, Yamasaki included normal volunteers and they defined more than grade 1 of the Kellgren-Laurence classification [19] as OA. The definition of joint space narrowing based on the Kellgren-Laurence classification is vague, and the exact definition of wrist joint space narrowing has never been published to our knowledge. In our study, the presence of one or more of osteophytes, joint space narrowing, subchondral sclerosis, or subchondral cysts was defined as OA. Furthermore, we strictly defined joint space narrowing as a distance of less than 1 mm between each bone in the joint. As a result, the kappa values for inter- and intra-observer agreement based on our definition of OA were comparable. Thus, the discrepancy of the incidence of OA between our study and that of Yamazaki et al. is likely due to the difference in both the criteria of participant inclusion and the definition of OA.

We investigated the prevalence of degenerative arthritic changes in the ulnar aspect of the wrist and found that the frequency of OA was highest at the DRUJ, and the second-most frequently identified the ulnolunate joint. In addition, the frequency of positive UV with OA (40.7 %, or 59 of 145 cases) was statistically higher than that of the control group (22.8 %, or 33 of 145 cases) (P=0.001). Nakamura et al. [20] reported that UV in 325 Japanese normal wrists increased with age, and positive UV (more than 1 mm) was present in 108 cases (32.2 %). Although we defined positive UV as more than 2 mm, the frequency of positive UV in our control group was nearly equal to that in the report of the Nakamura et al. and the frequency of positive UV with OA was higher than that without OA.

In order to identify the factors that are correlated with the presence of OA at the ulnar aspect of the wrist joint, we investigated various factors, including age, gender, and the configuration of the wrist and carpal alignment. Of these factors, the factor most influential to the presence of OA of the ulnar aspect of the wrist joint was UV, with an odds ratio of 1.645, indicating that the relative risk of OA of the ulnar aspect of the wrist joint increased by 1.645 times when UV increased by 1 mm. Previous biomechanical studies are in agreement with our results [21, 22, 23]. Werner et al. [21] reported that radial shortening or ulnar lengthening caused a significant increase in pressure at the DRUJ; the center of pressure was located more distally in the sigmoid notch of the radius, and moved from the central dorsal region of the sigmoid notch to the distal rim of the articulation. This non-physiological contact caused an incongruity in the articulation of the DRUJ, leading to OA. Palmer et al. [22] reported an increase in articular pressure at the ulnolunate articulation from 1.4 N/mm^2 to 3.3 N/mm^2, with an ulnar lengthening of 2.5 mm. Similarly, Fernandez [23] reported that post-traumatic deformity after a fracture in the distal end of the radius became symptomatic if the change in UV was more than 5 mm, causing OA in the DRUJ.

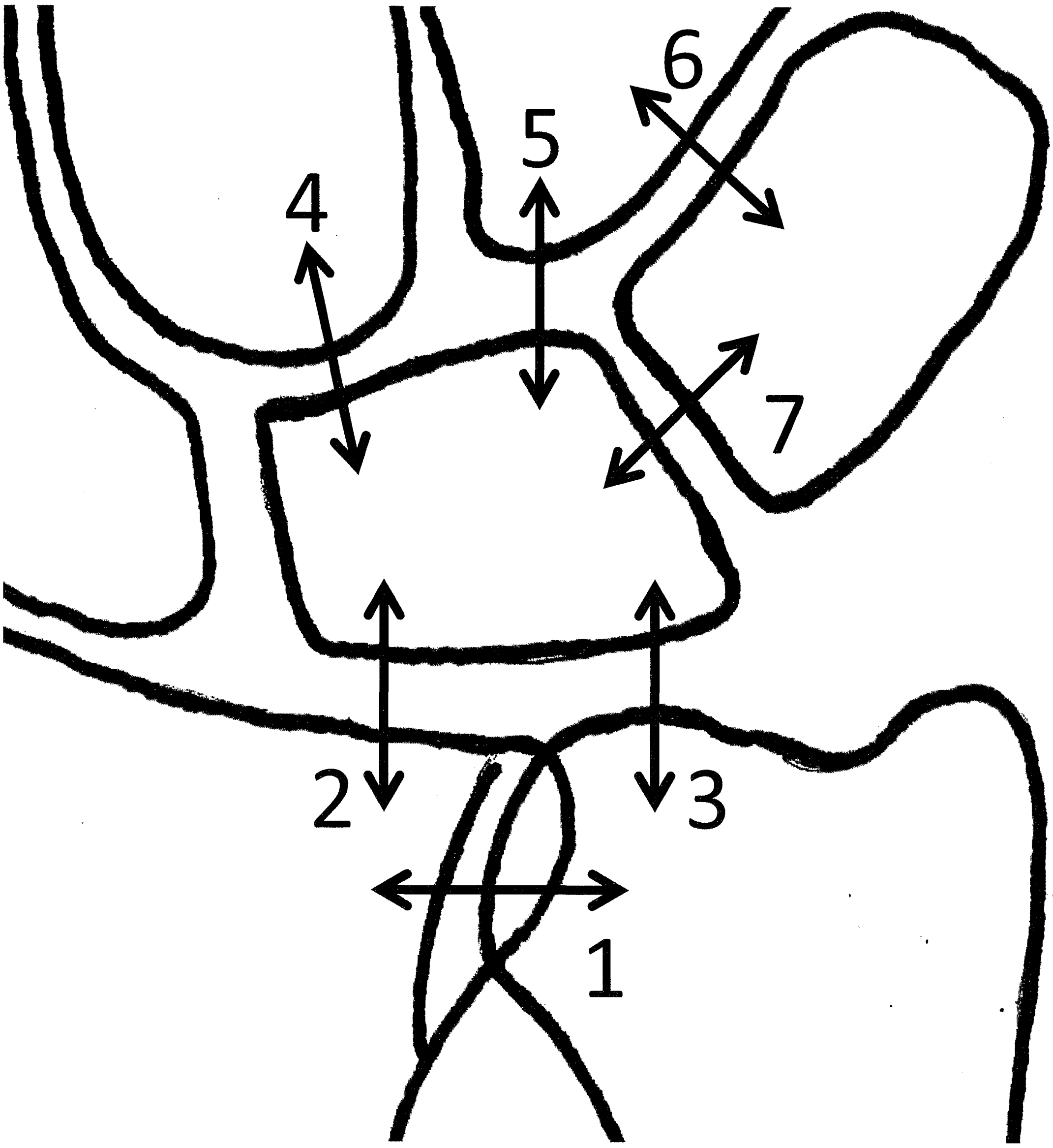
This study had several limitations. The first is that many of the patients enrolled in this study demonstrated some type of wrist problem. Therefore, our study may be affected by the characteristics of the patients enrolled in this study. It is very difficult to enroll enough normal volunteers to evaluate the incidence and distribution of OA in the ulnar aspect of the wrist. However, UV (0.61 mm) in our 145 select control cases without OA was almost equal to that of the normal volunteers [20]. As for the mean values of RI (25.8 degrees), CHR (54.4 %), VT (12.3 degrees), RLA (6.86 degrees), and RSA (52.4 degrees) in the control cases, normal Japanese values have not been reported; however, our results were almost consistent with mean values for Europeans and Americans [24, 25, 26]. The second limitation of this study was that our radiographic evaluations were based on static radiographs. Joint instability is one of the pathogeneses of OA, and dynamic instability of the joint derived from a soft tissue injury, such as TFCC injury cannot be sufficiently evaluated by static radiographs [27]. Therefore, we cannot comment on the influence of joint instability on OA in the ulnar aspect of the wrist. The third limitation was that we did not grade the radiographic changes of OA in each joint; rather, the features of OA were evaluated. Grading of the radiographic changes of OA would provide a more accurate evaluation of OA in the ulnar aspect of the wrist.

Further longitudinal study is needed to investigate that the case with positive UV prospectively progress to OA in the ulnar wrist.

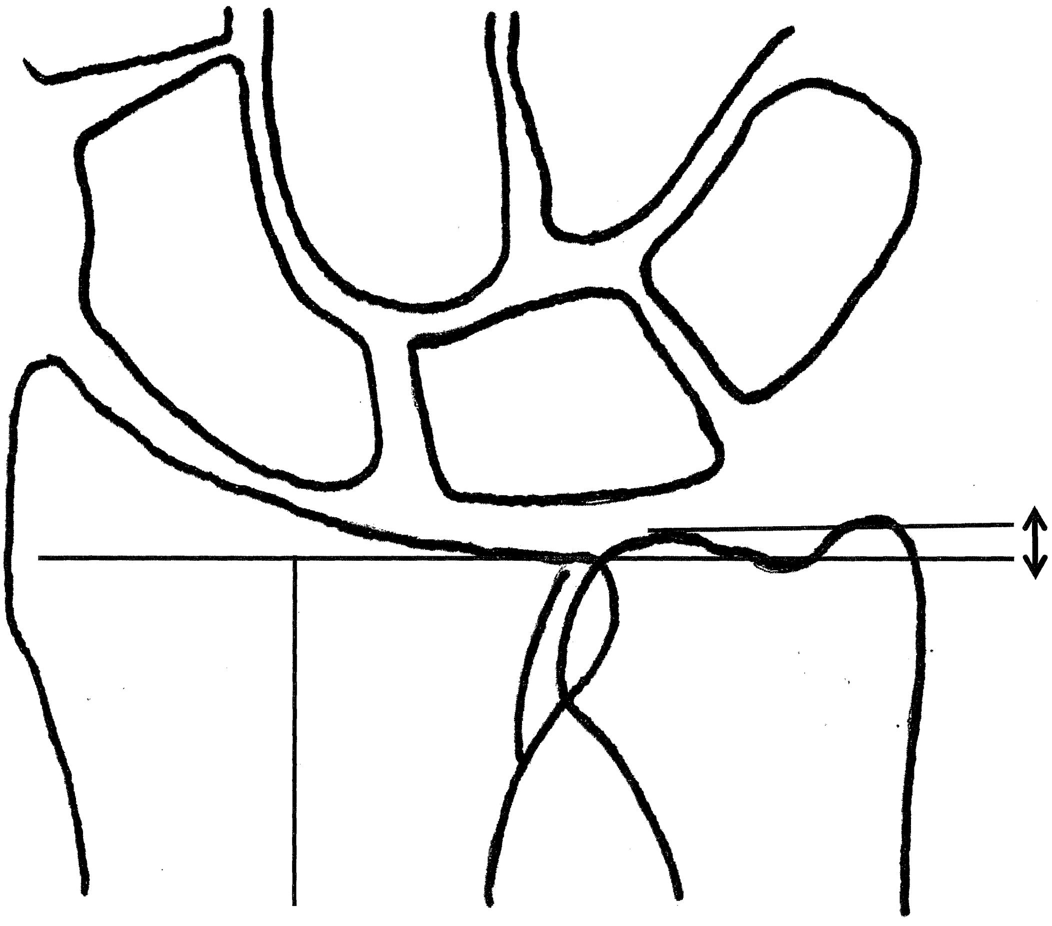
Conclusion

We found that primary OA in the ulnar aspect of the wrist was identified in 145 (12.8 %) of 1128 patients, and was the most frequent in the DRUJ and second-most in the ulnolunate joint. And UV was the most correlated with OA in the ulnar aspect of the wrist joint.

Based on the current results, we would propose early correction of positive UV in patients with ulnar abutment syndrome when conservative treatment fails, yet no clear evidence exists to support our proposition. Further clinical study should be performed to confirm that the lengthening procedure as an ulnar-shortening osteotomy for the early grades of ulnar abutment syndrome not only reduces wrist pain and disability, but also decreases the frequency of OA by improving the incongruence of the distal radioulnar joint.



1
2
3
4
5
6
7



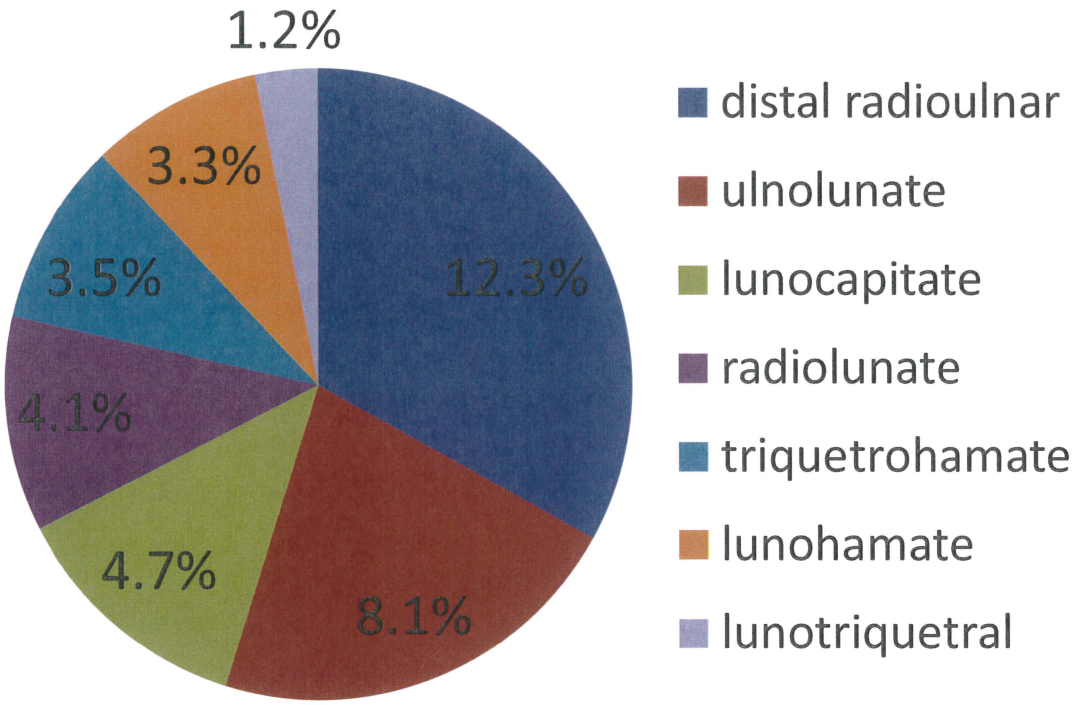

1.2%
3.3%
3.5%
12.3%
4.1%
4.7%
8.1%
distal radioulnar
ulnolunate
lunocapitate
radiolunate
triquetrohamate
lunohamate
lunotriquetral

Table 1 Characteristics of each variable with and without OA

Variable	Primary OA (N=145)	Control (N=145)
Gender	Male : 51	Male : 52
	Female : 94	Female : 93
Age	67.6±13.9	67.3±12.3
Radial inclination	25.3±2.7	25.8±2.2
Ulnar variance	1.37±1.5	0.61±1.2
Carpal height ratio	53.8±2.6	54.4±2.5
Volar tilt	12.7±4.1	12.3±3.7
Radiolunate angle	5.39±7.7	6.86±6.8
Radioscaphoid angle	53.8±7.6	52.4±7.1

Values are represented as the mean ± standard deviation.

Table 2 Correlation between osteoarthritis of the ulnar aspect of the wrist joint and variables

	ulnar aspect of the wrist joint	
Variable	Pearson's R	p Value
Gender	0.008	0.901
Age	0.005	0.932
Radial inclination	-0.137	0.022*
Ulnar variance	0.293	<0.001*
Carpal height ratio	-0.142	0.027*
Volar tilt	0.112	0.211
Radiolunate angle	-0.127	0.037*
Radioscaphoid angle	0.099	0.147

* : Statistically significant.

Table 3 Logistic Regression Analysis: Factors correlated with osteoarthritis of the ulnar aspect of the wrist joint

Variable	Odds Ratio	95% Confidence Interval		p Value
		Lower	Upper	
Radial inclination	0.856	0.765	0.958	0.007*
Ulnar variance	1.645	1.341	2.018	<0.001*
Carpal height ratio	0.861	0.776	0.956	0.005*
Radiolunate angle	0.921	0.877	0.984	0.21

Object variable: osteoarthritis of the ulnar aspect of the wrist joint

* : Statistically significant.

Table 4 Intraclass correlation coefficient (ICC) and kappa values

		ICC or kappa values for interobserver agreement		ICC or kappa values for intraobserver agreement	
ICC	Ulnar variance	0.96	(0.94-0.98)	0.97	(0.95-0.98)
	Radial inclination	0.87	(0.78-0.92)	0.91	(0.85-0.94)
	Carpal height ratio	0.78	(0.63-0.86)	0.88	(0.84-0.92)
	Volar tilt	0.84	(0.74-0.90)	0.91	(0.87-0.94)
	Radiolunate angle	0.71	(0.52-0.83)	0.92	(0.90-0.94)
	Radioscaphoid angle	0.70	(0.51-0.83)	0.88	(0.82-0.92)
kappa	OA of DRUJ	0.89	(0.82-0.93)	0.93	(0.89-0.94)
	OA of ulnolunate joint	0.82	(0.69-0.89)	0.87	(0.81-0.91)
	OA of radiolunate joint	0.64	(0.41-0.78)	0.66	(0.42-0.80)
	OA of triquetrohamate joint	0.66	(0.43-0.79)	0.84	(0.76-0.88)
	OA of lunohamate joint	0.67	(0.46-0.80)	0.81	(0.70-0.87)
	OA of lunocapitate joint	0.64	(0.41-0.79)	0.84	(0.76-0.89)
	OA of lunotriquetral joint	0.66	(0.43-0.79)	0.78	(0.66-0.88)

( ): 95% confidence interval