The Impact of Digit-related Radiographic Osteoarthritis of the Hand on Grip-strength and Upper Extremity Disability

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Abstract

Background Interpreting the impact of hand osteoarthritis (OA) on hand function is complicated owing to the multiple digits and joints in the hand.

Questions/purpose We determined the impact of digit-related radiographic OA on hand function in patients 65 years or older.

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All ICMJE Conflict of Interest Forms for authors and *Clinical Orthopaedics and Related Research* editors and board members are on file with the publication and can be viewed on request. Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

Methods We evaluated hand radiographs in 196 men and 182 women older than 65 years without shoulder or elbow pain who participated in the Korean Longitudinal Study on Health and Aging. Using the Kellgren and Lawrence criteria, we graded the 15 joints in each hand from 0 to 4 for OA, and evaluated hand function by measuring DASH scores and grip and pinch strength of dominant hands. We performed multiple linear regression analyses to evaluate associations between hand functions and the sum of Kellgren and Lawrence grade of each digit.

Results The sums of Kellgren and Lawrence grades for thumbs and middle fingers were independently associated with grip strength, and the sums of the Kellgren and Lawrence grades for thumbs and index fingers were independently associated with pinch strength after controlling for age and sex. DASH scores were independently associated with OA of the thumb, or index or middle finger, but not with OA of the ring or small finger.

Conclusions This study revealed cumulative effects of joint involvement and Kellgren and Lawrence grades of thumb and middle finger OA on grip strength, and thumb and index finger OA on pinch strength. Furthermore, OA of either of three radial digits was associated with more severe upper extremity disabilities.

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Introduction

Osteoarthritis (OA) is the most common age-related chronic disease and the leading cause of disability in the elderly [4]. Some studies have found that radiographic hand OA has a high prevalence among the elderly, ranging from 13% to 47% in Asian populations [26, 28] and 80% to 94% in white populations [2, 25, 27].

Involvement of different skeletal sites has different impacts on physical function. For example, studies have consistently noted the association between large joint OA, such as hip and knee OA, and lower extremity disability [19, 21–23]. However, interpreting the impact of OA on hand function seems to be complicated owing to the presence of multiple digits and joints. Furthermore, the thumb and fingers have different functional implications: the thumb and index finger are important for pinching and fine motions while the middle, ring, and small fingers are important for grip [1, 15, 24].

Reports on the impact of OA on hand function have tended to disagree. Baron et al. [3] reported that the Smith Hand Function test results correlated with hand strength, but that no correlation existed between these results and the degree of radiologic hand OA. Haara et al. [7] found that thumb carpometacarpal (CMC) OA rarely caused disability, whereas Zhang et al. [27] reported that patients with symptomatic hand OA had a 10% reduction in grip strength and functional limitations that affected several daily activities. Jones et al. [12] noted that hand OA at the distal interphalangeal (DIP) and thumb CMC joints had a substantial effect on hand function, strength, and pain, but did not specify which fingers were affected by DIP OA.

In this study, we hypothesized that the impacts of OA on hand function depended on the digits affected. Therefore, we (1) evaluated the prevalence of radiographic hand OA in Koreans older than 65 years and (2) determined the impact of digit-related radiographic OA on hand function as measured by grip and pinch strengths and DASH scores [8].

Patients and Methods

This study was conducted as a substudy of the Korean Longitudinal Study on Health and Aging (KLoSHA). The KLoSHA was designed as a population-based prospective cohort study of health, aging, and common geriatric diseases in the elderly Korean population, conducted from September 2005 to August 2006, and involving residents of

Seongnam City, South Korea. The institutional review board of the authors' hospital approved this cohort-based study, and all participants gave informed consent.

Candidates were randomly drawn from a roster of patients 65 years or older using a computer-generated list of resident registration numbers. We invited 1118 individuals to participate in this study by letter and telephone, of which 696 agreed to participate (a response rate of 62.3%). We recorded demographic data and obtained AP hand radiographs. A specially trained nurse conducted an interview, asking patients questions regarding a current or past history of pain at the shoulder, elbow, hand, hip, knee, foot and ankle, or spine. Grip and pinch strengths were measured in dominant hands. DASH questionnaires were used at the point of enrollment. We excluded 58 patients who had a history of trauma in the hand or wrist or prior surgery on the upper extremity. We also excluded 252 patients with symptoms of shoulder or elbow pain, and eight patients with rheumatoid arthritis. Therefore, 378 patients were included in the analysis. Mean patient age was 75.3 ± 7.4 years (range, 65–92 years) and 196 (51.9%) patients were men (Table 1). There was no difference between the age distributions of men and women; however, women had a greater mean BMI (Table 1).

All radiographic images were acquired digitally using a picture archiving and communication system (PACS; Impax; Agfa, Antwerp, Belgium), which also was used to do the assessments described below. Two of the authors (HL, HG) evaluated AP radiographs of both hands. These authors are orthopaedic surgeons and were blinded to information for each patient regarding the use of the Kellgren and Lawrence grading criteria for OA severity [13]. We evaluated the intraobserver reliability, having the examiner repeat all radiographic assessments after 3 weeks, and evaluated interobserver reliabilities by having two examiners read all radiographic assessments independently. We tested

Table 1. Patient demographics

Variables	Male (n = 196)	Female (n = 182)	p value*
Average age (years)	75.6 ± 7.6	75.0 ± 7.2	$p = 0.125$
Percentage of patients between			
65–69 years	26.0%	25.3%	
70–74 years	32.1%	34.6%	
75–79 years	15.8%	18.1%	
Older than 80 years	26.0%	22.0%	
Height (cm)	163.8 ± 7.1	151.3 ± 5.2	$p < 0.001$
Weight (kg)	64.8 ± 8.2	57.3 ± 9.2	$p < 0.001$
BMI (kg/m^2)	23.8 ± 3.8	24.9 ± 3.2	$p = 0.021$

* p using Student's t-test.

intraobserver and interobserver reliabilities of radiographic grading scale assessments using Cohen's kappa coefficients, and use descriptive statistics to report the prevalence of hand OA. The Cohen's kappa coefficient of the intraobserver reliability for assessment of radiographic grading scales was 0.897 ($p = 0.028$), and for interobserver reliability was 0.826 ($p = 0.035$). Thus, we used the scale measurements taken by one of the authors in the analyses.

Fifteen joints of each hand (four DIP, four proximal interphalangeal [PIP] joints, five metacarpophalangeal [MCP], the first interphalangeal [IP], and the first CMC) were evaluated for osteophytes, joint space narrowing, sclerosis, and cysts. The joints of both hands were graded from 0 to 4 for OA according to the Kellgren and Lawrence criteria: Grade 0, none; Grade 1, possible osteophytes only; Grade 2, definite osteophytes and possible joint space narrowing; Grade 3, moderate osteophytes with definite joint space narrowing and some sclerosis; and Grade 4, large osteophytes and bony sclerosis with severe joint space narrowing [13]. Grades 2, 3, and 4 indicated the presence of OA. The most frequently applied definition of radiographic OA was a Kellgren and Lawrence Grade 2 or greater in at least one hand joint [17]. If the patient had at least one hand joint with radiographic OA, we classified them as having hand OA. Also, we classified the OA into digit-joint group, such as DIP, PIP, and MCP joints in each of the four fingers and IP, MCP, and CMC joints in the thumb. If at least one joint of that digit-joint group had radiographic OA, that group had OA. To quantify the overall radiographic severity of hand OA in each digit-joint group, we summed the Kellgren and Lawrence grades of three joints (DIP, PIP, MCP) in each of the four fingers, and of the IP, MCP, and CMC joints in the thumb [5].

Grip strengths of the dominant hand were measured in a standardized manner [18]. With the arm, forearm, and wrist in a neutral position, two consecutive attempts (with a 1-minute interval) were measured in kilograms using a Jamar hydraulic dynamometer (5030J1, Sammons Preston, Bolingbrook, IL, USA). Three point pinch strength of the dominant hand was measured using a Jamar pinch gauge (B&L PG-60, Sammons Preston) in the same manner as pinch strength. We used average values for statistical analysis.

The DASH questionnaire was developed as a self-administered, region-specific instrument to measure functional status and degrees and levels of symptoms in patients with an upper extremity disability [8]. The questionnaire contained 30 items, 21 of which addressed difficulties with specific tasks, five evaluated symptoms, and one each addressed social function, work function, sleep, and confidence. Response options ranged from 1 to 5, and overall scores ranged from 0 and 100 (higher scores represent poorer upper extremity functions). The mean normative DASH score value in healthy patients in the United States has been

reported to be 10.10 ± 14.68 points [9]. The DASH is well known for its reliability and validity for evaluations of upper extremity dysfunctions [8, 10, 11]. In this study, we used the Korean version of the DASH questionnaire (K-DASH) [16]. This version was developed using a cross-cultural adaptation procedure, and was assessed for reliability and validity in patients with arm, shoulder, and hand disabilities [16].

The variables considered to affect grip and pinch strength and DASH scores were age, sex, and Kellgren and Lawrence grade sums of the affected digit in the dominant hand. We performed multiple linear regression analyses with either variable selection to assess the relative contributions of radiographic severity (sum of Kellgren and Lawrence grade of three joints on each digit) on grip and pinch strength, and DASH score. Age and sex were covariates in this model. Sex was coded as 0 for women and 1 for men. We considered p values less than 0.05 statistically significant.

Results

The overall prevalence of radiographic hand OA was 58.2% (95% CI, 55.3%–61.1%) in men and 67.0% (95% CI, 60.4%–73.6%) in women. The prevalence of radiographic hand OA increased with age in men and women. We recorded the prevalence of radiographic hand OA in both hands regarding age, location, and number of joints (Table 2).

The variables of age, sex, and Kellgren and Lawrence grade were related to grip strength of the dominant hand and DASH scores by simple linear analysis and were entered into the multiple linear regression analysis (Table 3). Multiple linear regression analysis showed that age and sex independently predicted grip and pinch strengths and DASH scores, and that older age and female sex were associated with lower grip and pinch strength and greater disability (Table 4). Kellgren and Lawrence grade sums of the thumb and the middle finger were independently associated with grip strength, and Kellgren and Lawrence grade sums of the thumb and the index finger were independently associated with pinch strength. DASH scores were independently associated with OA of the thumb and index and middle fingers, but not with OA of the ring and small fingers. Middle finger OA had a larger beta value than the other two radial digits for predicting DASH scores. A multiple linear regression model that included age, sex, and OA of the hand explained 54.9% ($R^2 = 0.549$, $p < 0.001$) of the observed variability of grip strength, of which hand OA accounted for 8.6% ($R^2 = 0.086$, $p = 0.001$). Age, sex, and OA of the hand explained 55.5% ($R^2 = 0.555$, $p < 0.001$) of the variability of the pinch strength, of which hand OA accounted for 5.7% ($R^2 = 0.057$, $p = 0.001$). This model explained

Table 2. Crude prevalence of radiographic hand OA in both hands

Variable	Men (%)		Women (%)	
Patient age range				
65–69 years	37.3 (95% CI, 33.2–41.4)		41.3 (95% CI, 36.5–46.1)	
70–74 years	49.2 (95% CI, 43.9–54.5)		66.7 (95% CI, 62.7–70.7)	
75–79 years	64.5 (95% CI, 59.3–69.7)		75.8 (95% CI, 70.2–81.4)	
Greater than 80 years	86.3 (95% CI, 81.6–91.0)		90.0 (95% CI, 85.8–94.2)	
Location	Right	Left	Right	Left
Thumb				
IP	18.0	17.1	20.2	21.4
MCP	4.9	4.1	7.2	5.4
CMC	15.8	13.2	15.4	12.2
Second finger				
DIP	13.8	14.2	18.9	16.1
PIP	5.1	6.1	6.2	3.9
MCP	3.6	3.6	5.0	2.2
Third finger				
DIP	19.9	17.9	24.4	25.0
PIP	5.1	5.1	10.6	8.9
MCP	3.1	3.6	3.3	2.2
Fourth finger				
DIP	15.3	15.8	17.2	16.3
PIP	7.1	6.6	6.7	7.2
MCP	4.1	1.0	3.9	1.7
Fifth finger				
DIP	18.8	14.8	26.1	22.8
PIP	7.1	6.1	15.0	12.2
MCP	4.1	2.0	4.4	2.2
Total number of OA joints in each patient				
0	41.8		33.0	
1	14.8		12.1	
2	9.7		9.9	
3	8.2		13.2	
4	6.6		6.6	
Greater than or equal to 5	18.9		25.3	

IP = interphalangeal; DIP = distal interphalangeal; PIP = proximal interphalangeal; MCP = metacarpophalangeal.

32.7% ($R^2 = 0.327$, $p < 0.001$) of the variability of DASH scores, of which, hand OA accounted for 6.0% ($R^2 = 0.060$, $p = 0.002$).

Discussion

Interpreting the impact of hand OA on hand function seems to be complicated owing to the presence of multiple

Table 3. Simple linear regression analysis of predictors of hand power and DASH score in elderly

Variables	Grip power			Pinch power			DASH score		
	b*	p value	95% CI	b*	p value	95% CI	b*	p value	95% CI
Age	−0.481	$p < 0.001$	46.691–65.179	−0.093	$p < 0.001$	−0.124 to −0.062	0.801	$p < 0.001$	0.564–1.038
Sex	11.663	$p < 0.001$	10.131–13.195	3.050	$p < 0.001$	2.695–3.406	−11.949	$p < 0.001$	−15.440 to −8.457
Sum of Kellgren-Lawrence grade (dominant hand)									
Thumb	−1.451	$p < 0.001$	−2.106 to −0.795	−0.258	$p = 0.002$	−0.420 to −0.097	2.256	$p < 0.001$	1.012–3.499
Second finger	−1.500	$p < 0.001$	−2.205 to −0.795	−0.324	$p < 0.001$	−0.496 to −0.151	1.661	$p = 0.017$	0.295–3.027
Third finger	−3.678	$p < 0.001$	−5.279 to −2.077	−0.678	$p = 0.001$	−1.073 to −0.284	5.555	$p < 0.001$	2.473–8.637
Fourth finger	−1.104	$p = 0.002$	−1.790 to −0.418	−0.193	$p = 0.025$	−0.361 to −0.025	1.312	$p = 0.049$	−0.004 to 2.601
Fifth finger	−1.002	$p = 0.004$	−1.682 to −0.322	−0.193	$p = 0.022$	−0.359 to −0.028	1.075	$p = 0.045$	−0.024 to 2.074

* b = unstandardized coefficient beta.

Table 4. Multiple linear regression analysis of predictors of hand power and DASH score in elderly

Variables	Grip power			Pinch power			DASH score		
	b*	p value	95% CI	b*	p value	95% CI	b*	p value	95% CI
Age	-0.489	p < 0.001	-0.592 to -0.387	-0.103	p < 0.001	-0.128 to -0.078	0.816	p < 0.001	0.560-1.072
Sex	12.079	p < 0.001	10.722-13.435	3.154	p < 0.001	2.826-3.481	-12.221	p < 0.001	-15.595 to -8.847
Sum of Kellgren-Lawrence grade (dominant hand)									
Thumb	-1.054	p = 0.045	-1.829 to -0.278	-0.280	p = 0.032	-0.492 to -0.078	1.530	p = 0.045	0.032-3.028
Second finger	-0.870	p = 0.061	-1.780 to 0.039	-0.256	p = 0.025	-0.480 to -0.032	0.626	p = 0.048	-1.037 to 2.289
Third finger	-2.170	p = 0.024	-4.058 to -0.282	-0.356	p = 0.134	-0.822 to 0.110	3.973	p = 0.034	0.299-7.648
Fourth finger	-0.030	p = 0.950	-0.969 to 0.909	0.055	p = 0.639	-0.177 to 0.287	-0.115	p = 0.901	-1.940 to 1.709
Fifth finger	-0.093	p = 0.838	-0.988 to 0.801	-0.028	p = 0.801	-0.249 to 0.193	-0.271	p = 0.759	-2.009 to 1.466

* b = unstandardized coefficient beta.

digits and joints in the hand. We attempted to evaluate the prevalence of radiographic hand OA, and determine the impact of digit-related radiographic OA on hand function regarding grip and pinch strengths and DASH scores in Koreans older than 65 years. This study reveals a cumulative effect of joint involvement and Kellgren and Lawrence grades of thumb and middle finger OA on grip strength, and thumb and index finger OA on pinch strength. Furthermore, OA of either of three radial digits was associated with more severe upper extremity disabilities.

Several limitations of this study deserve mention. First, although DASH was a validated tool that measured the symptoms and functional statuses of patients with upper extremity disorders, a more region-specific tool probably would have better reflected the association between hand function and hand OA. However, by excluding patients with elbow and shoulder pain in this study, we believed DASH could sufficiently reflect impairment of the hand. Second, we excluded patients with shoulder and elbow pain to avoid the effects of these joints on hand function. However, those excluded may have OA of the shoulder or elbow and a greater possibility of coexistent hand OA than the general population, thus the prevalence of hand OA may have been underestimated.

The prevalence of hand OA in our patients was intermediate, between those reported for Chinese and US populations. Zhang et al. [28] compared the prevalence of hand OA in Chinese in China to that of white people living in the United States, and found that only 44.5% of men and 47.0% of women had radiographic hand OA in China, but that 75.2% of men and 85.0% of women had radiographic hand OA in the United States. Yoshida et al. [26] also concluded that the prevalence of hand OA in Japanese patients was lower than in white patients. Zhang et al. [28] considered that the low prevalence of hand OA in the Chinese was attributable to a lower prevalence of disease-susceptibility genes in Chinese patients, whereas Yoshida et al. [26] suggested that genetic background and environmental or cultural (lifestyle) factors probably explained the low prevalence of OA in Japanese patients.

Many authors have studied the effect of OA on hand function and have had contradictory results [3, 5, 7, 14, 20, 27]. Baron et al. [3] reported no correlation between hand strength and the degree of radiologic hand OA. Haara et al. [7] found that thumb CMC OA, despite its prevalence, rarely caused disability. However, Dominick et al. [5] reported that the radiographic severity of hand OA was associated with grip and pinch strength, and Labi et al. [14] showed that radiographic OA severity was a stronger predictor of grip strength than the number of affected joints. Zhang et al. [27] reported that patients with symptomatic hand OA showed a 10% reduction in grip strength and had functional limitations that affected several daily activities.

Navsarikar et al. [20] reported that the DASH scores of patients with psoriatic arthritis correlated with grip strength and the number of active joints. The discrepancies in the effect of OA on hand function in the previous studies may be attributable to the fact that many hands with OA are not symptomatic, or to the presence of multiple digits and joints in the hand that complicates interpretation of the impact of OA on hand function. In this study, patients with hand OA had less grip and pinch strength than those without hand OA. We also confirmed the cumulative effect of joint involvement and the sum of Kellgren and Lawrence grades on hand functions.

Few reports have studied the relationship between the location of hand OA and hand function [5, 12]. Jones et al. [12] noted that hand OA at the DIP and thumb CMC joints had substantial effects on hand function, but they did not specify which fingers were affected by DIP OA. Dominick et al. [5] reported that, among individuals with radiographic hand OA, increasing radiographic severity was associated with reduced grip and pinch strength, and that radiographic OA in specific locations, such as CMC and MCP joints, might have been at particular risk for reduced hand strength and function. Some authors have investigated the contributions made by specific digits to grip strength, and revealed that the middle finger contributes 30% to 35%, the index finger 25% to 30%, the ring finger 22% to 25%, and the small finger 15% to 18% of grip strength [1, 24]. Our results supported these findings that the middle finger contributes most to grip strength with a larger beta value than other digits, but also revealed that the thumb was an independent predictor of grip strength.

We showed that hand OA explained only 5.7% to 8.6% of the variation of hand grip and pinch strengths, and 6% of the variation of upper extremity disability, which was comparable to the findings of Jones et al. [12], who reported that hand OA contributed 5.7% to 10% of variation in pain, function, and grip strength. In their study, the associations between function and grip strength appeared to be mediated by pain, and differences in sex persisted after adjusting for age and OA severity. We also found a difference in sex in our study in the multiple linear regression analyses: women reported more disability after controlling for age and degree of hand OA. Dziedzic et al. [6] also found that women were more vulnerable to hand problems affecting daily life.

Our study revealed the cumulative effect of joint involvement and Kellgren and Lawrence grades of thumb and middle finger OA on grip strength, and thumb and index finger OA on pinch strength. In addition, OA of either of three radial digits was associated with more severe upper extremity disabilities. This information may help in counseling patients with hand OA regarding progression of arthritis and hand function.

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