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Hand strenght and dexterity in interphalangeal hand osteoarthritis and effects of osteophyte formations

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Abstract

Background: Hand osteoarthritis (HOA) is a complex disorder with various subtypes characterized with predominance of different features. It is challenging to estimate the severity of hand disability in HOA, since contribution of different disease components to clinical burden is yet to be clarified. The aim of the study is to investigate hand functions in nonerosive interphalangeal hand osteoarthritis (HOA) without inflammatory features, and search for effects of osteophyte formations detected by radiography and ultrasound on functionality.

Methods: Thirty one HOA patients and 20 healthy subjects with similar age, gender, body mass index were included. Hand functions were evaluated by self-reported questionnaires and objective strength and dexterity measurements. A total of 459 interphalangeal joints were evaluated and scored by radiography and ultrasound for osteophyte formations.

Results: Strength and dexterity measurements were similar between groups. Self-reported functionality was hampered in HOA group but not statistically significant. Osteophyte scores obtained by ultrasound and radiography were significantly higher in HOA group. Osteophyte scores obtained by ultrasound were higher than the scores obtained by radiography. Ultrasound scores showed no correlation with any of the parameters while osteophytes scores obtained by radiography partially showed a significant negative correlation with assembly part of dexterity testing.

Conclusions: No significant difference observed in hand strength and dexterity in nonerosive interphalangeal HOA patients without signs of inflammation when compared to healthy subjects. Osteophyte formations prominent enough to be detected by radiography may have a negative effect on hand dexterity.

Keywords: Hand, Osteoarthritis, Ultrasound, Disability, Imaging

Background

Hand osteoarthritis (HOA), the degenerative disease of hand joints, is the most common form of hand arthritis. Typical symptoms include joint pain, tenderness, swelling, bony enlargements and hand deformities. Additionally, hand functions may be altered in various degrees. HOA is a complex disorder with various subtypes

characterized with predominance of different features and affected joints, such as thumb-base OA, interphalangeal OA, nodular OA, erosive OA. Structural alterations like osteophyte formations, joint space narrowing, erosions also show diversity according to disease subtype or disease stage. Presence of inflammation further contributes to disease burden. Considering such variety, it is challenging to estimate the severity of hand disability in patients with different phenotypes, since contribution of different disease components to clinical burden is yet to be clarified [1–5].

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Conventional radiography, is still the standart imaging modality in diagnosis and assessing the structural damage, as osteophytes and joint space narrowing can easily be detected. However, radiographic disease severity does not always correlate with hand disability and symptoms [6–8]. There is an increasing trend of using ultrasound (US) imaging in HOA, as several studies imply US may be more sensitive in detecting structural abnormalities [9–12]. Furthermore, with US, detection and grading of inflammatory changes is also possible [13, 14]. Correlation of functional loss and structural changes also investigated using US in previous studies and results are controversial [14–18]. Some studies revealed an association between inflammatory changes (ie. synovitis, doppler activity) and pain, hand functions [15, 18], while other studies revealed no correlation between US severity and symptoms [13, 16].

In order to further investigate the effects of different disease components on hand disability, in this study, we evaluated hand strenght and dexterity of a particular subgroup of HOA patients, interphalangeal OA, with no inflammatory and erosive changes and compared with healthy subjects with similar demographics. We particularly searched for any correlation between functional measurements and osteophyte formations detected either by radiography or ultrasound.

Method

All procedures in this study were approved by the institutional ethics committee and were therefore performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

Consecutive patients attending to Hacettepe University Medical School, Physical and Rehabilitation Medicine outpatient clinic with hand pain were evaluated to determine eligibility for participation to the study. Subjects fullfilling the American Collegue of Rheumatology

(ACR) clinical classification criteria for HOA [19], between ages of 45 and 65 further evaluated. Patients aged over 65 were excluded in order to avoid confounding effects of senility on deterioration of hand strenght and dexterity. Patients with concomittant conditions possibly affecting hand functions were excluded (Table 1). Age, gender, body mass index (BMI), dominant hand, smoking status and menopausal status were recorded.

A group of healthy volunteers of similar age, BMI and gender properties, without any hand pain were clinically evaluated. Volunteers without tenderness, swelling, deformity, nodules in any hand joint were included as control subjects (Table 2).

Single hand for each subject were included in the study, preferably the dominant hand in both groups. When dominant hand did not meet the inclusion criteria, non-dominant hand included.

In HOA group, tender joint count, swollen joint count, count of joints with nodules, global hand pain assessed by visual analogue scale (VAS) were recorded. Self reported functionality were assessed with physical function subscale of the Australian Canadian Osteoarthritis Hand Index (AUSCAN-PF) 5 – point Likert version and with the Health Assessment Questionnaire Disability Index (HAQ-DI).

In both groups, anteroposterior x – ray of included hands were evaluated. Patients with thumb-base OA and patients with erosions were discarded. Osteophytes in the first interphalangeal (IP) joint, second to fifth proximal interphalangeal (PIP) joints, and second to fifth distal interphalangeal (DIP) joints were evaluated according to Osteoarthritis Research Society International atlas and were graded between 0 and 3, semiquantitatively [20]. The total osteophyte score of the hand, number of joints with any osteophyte, the greatest osteophyte score in single joint were recorded. US examination of included hands were performed by General Electric Logic

Table 1 Inclusion and exclusion criteria

<i>Inclusion criteria</i>	<i>Exclusion Criteria</i>
Fulfilling ACR criteria	Thumb-base OA
Age between 45 and 65	Erosive OA
Interphalangeal OA	Rheumatoid arthritis, psoriatic arthritis
	Gout, pseudogout, haemochromatosis
	Tenosynovitis, epicondylitis
	Trigger finger, Dupuytren's contracture
	Carpal tunnel syndrome, polyneuropathy
	Diabetic cheiroarthropathy
	Fibromyalgia
	Hand injury or hand surgery within 6 months
	Intraarticular injection of any kind to any hand joint within 3 months
	Inflammatory changes in US examination

Table 2 Demographics of both groups and clinical findings in hand osteoarthritis group

	Control	HOA	p
Patient/hand no.	20/20	31/31	
Total no. of evaluated joints ^c	180	279	
Age, years ^a	53 (46–63)	56 (47–63)	0,072
BMI ^a	30,45 (21,48 - 44,4)	27,57 (20,76 - 43,75)	0,195
Gender, female ^b	15 (95,0)	30 (96,8)	0,750
Dominant hand evaluated ^b	18 (90,0)	30 (96,8)	0,315
Ever smokers ^b	9 (45,0)	10 (32,3)	0,358
Postmenopausal females ^b	17 (89,5)	26 (86,7)	0,770
Symptom duration, months ^a		54,00 (6,00–240,00)	
Tender joint count ^a		5,00 (1,00–9,00)	
Swollen joint count ^a		0,00 (0,00 – 0,00)	
Joint with nodules count ^a		2,00 (0,00–9,00)	
VAS global hand pain ^a		5,50 (3,00–9,00)	

^aMedian (min – max), ^bNumber (percentage), ^c2nd – 5th DIP and PIP, 1st IP joints were evaluated, HOA Hand osteoarthritis, BMI Body mass index, VAS Visual analog scale, AUSCAN Australian Canadian Osteoarthritis Hand Index

P5 ultrasound machine with a 12 Hz linear transducer (Fig. 1a). Patients with inflammatory changes (synovial effusion, synovial hypertrophy, power Doppler activity) were discarded. Osteophytes were graded between 0 and 3 semiquantitatively in the first IP, second to fifth PIP and second to fifth DIP joints according to the OMER-ACT suggestions (Figure 1b) [21]. The total osteophyte score of the hand, number of joints with any osteophyte, the greatest osteophyte score in single joint were recorded (Table 3).

US evaluations were undertaken by the same researcher with musculoskeletal ultrasound experience, who was blind to the clinical information of the subjects. Similarly radiography scorings were made by another single blind researcher.

Grip strength was measured using a Jamar dynamometer in the sitting position with the shoulder adducted and neutrally rotated, the elbow flexed at 90 degree, forearm and wrist in neutral position. Three consecutive

attempts (with 1 min interval) were measured in kilograms and average values were used for statistical analysis. Pinch strength was measured by a hydraulic pinch gauge in the same position. Tip to tip pinch, lateral pinch, three point pinch were evaluated and three consecutive attempts (with 1 min interval) were measured in kilograms and average values were used for statistical analysis. Hand dexterity was evaluated with Purdue pegboard dexterity test. Initially, each hand individually evaluated by hand test, comprising inserting pins to the holes on the board from top to bottom, using only the evaluated hand. Number of pins inserted in 30 s was recorded. Then assembly test was applied, comprising assembling of pins, collars and washers in the holes. Number of parts assembled in 1 minute were counted and scored.

For statistical analyses the SPSS V22.0 software package was used.

Normality for variables were assessed with Shapiro – Wilks test. Normally distributed continuous variables

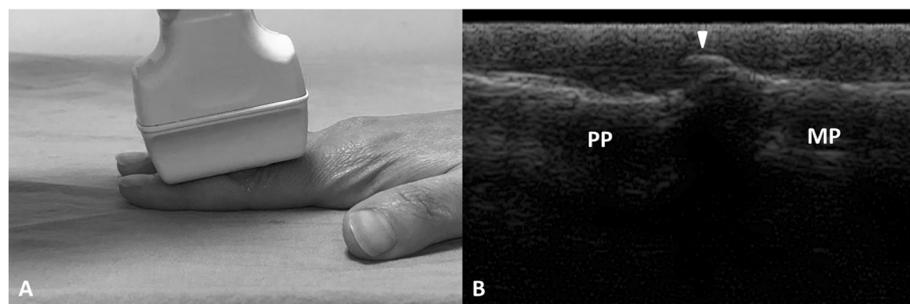


Fig. 1 a Probe positioning for dorsal longitudinal view of proximal interphalangeal joint. Same positioning applied for examination of distal interphalangeal and 1st interphalangeal joints. b An osteophyte formation (arrowhead) observed as a cortical protrusion in proximal interphalangeal joint. MP: middle phalanx, PP: proximal phalanx

Table 3 Comparison of HAQ, strength, dexterity, radiography and ultrasound scores between groups

	<i>Control</i>	<i>HOA</i>	<i>p</i>
<i>HAQ-DI</i> ^a	0,22 ± 0,21	0,35 ± 0,36	0,332
<i>AUSCAN-PF</i> ^a	8,55 ± 8,99	13,95 ± 11,11	0,111
Hand strength measurements, kg^a			
<i>Grip</i>	23,55 ± 6,63	21,66 ± 5,86	0,581
<i>Lateral pinch</i>	6,54 ± 1,25	6,10 ± 1,56	0,186
<i>Tip to tip pinch</i>	4,64 ± 1,47	4,43 ± 1,22	0,786
<i>Three point pinch</i>	5,95 ± 1,64	5,45 ± 1,54	0,549
Purdue peg board dexterity scores^a			
<i>No. of pins inserted in 30 s</i>	11,90 ± 1,74	11,29 ± 1,49	0,139
<i>No. of parts assembled in 1 min</i>	5,79 ± 1,01	6,17 ± 1,73	0,824
Ultrasound scores^b			
<i>Total OP score per hand</i>	1,00 (0,00–6,00)	7,00 (0,00–17,00)	< 0,001
<i>Joint with OP count</i>	1,00 (0,00–5,00)	5,00 (0,00–8,00)	< 0,001
<i>Greatest OP score in single joint</i>	1,00 (0,00–2,00)	2,00 (0,00–3,00)	< 0,001
Radiography scores^b			
<i>Total OP score per hand</i>	0,00 (0,00–4,00)	3,00 (0,00–12,00)	< 0,001
<i>Joint with OP count</i>	0,00 (0,00–4,00)	3,00 (0,00–8,00)	< 0,001
<i>Greatest OP score in single joint</i>	0,00 (0,00–1,00)	1,00 (0,00–3,00)	< 0,001

^amean ± SD, ^bmedian (min – max), *HOA* Hand osteoarthritis, *HAQ-DI* Health Assessment Questionnaire Disability Index, *AUSCAN-PF*: Australian Canadian Osteoarthritis Hand Index physical function subscale, *OP*: osteophytes

were compared with t – test, otherwise with Mann – Whitney – U test. Nominal variables were compared with Chi – Square test. Correlations were analyzed with Spearman's Rho. *P* < 0.05 accepted as statistically significant in all analyses.

Results

Thirty one HOA patients and 20 control subjects were included in the study. A total of 459 joints were evaluated. Demographics of all subjects and clinical properties of HOA patients were given in Table 2. No significant

Table 4 Correlations between clinical findings, osteophyte scores and functional tests in hand osteoarthritis group

		Hand strength measurements				Purdue pegboard dexterity scores	
		<i>Grip</i>	<i>Lateral pinch</i>	<i>Tip to tip pinch</i>	<i>Three point pinch</i>	<i>Pins inserted</i>	<i>Parts assembled</i>
Ultrasound scores							
<i>Total OP score per hand</i>	<i>cc</i>	0,136	0,142	0,138	0,098	0,030	0,087
	<i>p</i>	0,136	0,470	0,459	0,602	0,872	0,642
<i>Joint with OP count</i>	<i>cc</i>	0,092	0,039	0,046	–0,010	–0,046	0,065
	<i>p</i>	0,622	0,845	0,804	0,956	0,808	0,729
<i>Greatest OP score in single joint</i>	<i>cc</i>	0,002	0,196	0,097	0,049	0,090	0,110
	<i>p</i>	0,993	0,316	0,603	0,793	0,631	0,555
Radiography scores							
<i>Total OP score per hand</i>	<i>cc</i>	–0,033	–0,060	0,074	0,096	–0,255	–0,435
	<i>p</i>	0,855	0,763	0,692	0,606	0,166	0,014
<i>Joint with OP count</i>	<i>cc</i>	–0,027	0,067	0,069	0,140	–0,281	–0,424
	<i>p</i>	0,885	0,734	0,713	0,452	0,125	0,017
<i>Greatest OP score in single joint</i>	<i>cc</i>	0,019	0,016	0,088	0,050	–0,106	–0,262
	<i>p</i>	0,919	0,937	0,637	0,791	0,571	0,154

cc Correlation coefficient, *VAS* Visual analog scale, *AUSCAN-PF* Australian Canadian Osteoarthritis Hand Index physical function subscale, *HAQ-DI*: Health Assessment Questionnaire Disability Index, *OP* Osteophytes

differences were detected in demographics between groups.

HAQ-DI, AUSCAN-PF scores, hand strength and dexterity measurements and imaging scores of both groups were presented in Table 3. HAQ-DI and AUSCAN-PF scores were higher in HOA group yet not statistically significant. Strength and dexterity measurements were similar between groups. Osteophyte scores obtained by ultrasound and radiography were significantly higher in HOA group. Osteophyte scores obtained by ultrasound were higher than the scores obtained by radiography.

Correlations between functional tests and imaging findings were evaluated in hand OA group (Table 4). US scores showed no correlation with any of the parameters while total osteophyte scores and total number of joints with osteophytes obtained by radiography showed a significant negative correlation with assembly part of dexterity testing.

Discussion

HOA is a common joint disorder with potential debilitating effects on quality of life. However, true disease burden is still unclear as HOA is a diverse disease with different subtypes and different predominant features. There are various tools to assess hand functions in HOA comprising self-reported questionnaires and indices, strength measurements, hand function and dexterity tests consisting specific tasks [22, 23]. However, the optimal way to assess hand functions in HOA is also unclear as a standardized assessment core set covering all elements of functionality is lacking [24]. Studies examining the effects of HOA on functionality have conflicting results. Bagis et al. [3] investigated effect of osteoarthritis on hand function in the postmenopausal women revealing lowered grip, pinch strengths in HOA. Dominick et al. [4] demonstrated hampering effects of HOA on hand strength and reported that deterioration of grip strength was most strongly associated with thumb-base OA. Alterations in Moberg pick up and Purdue pegboard performances were also observed in HOA patients [2, 5]. Contrarily, Özkan et al. [25] found no difference in grip and pinch strengths between radiographic HOA patients and healthy controls but HAQ and Dreiser scorings was worse in the HOA patients than healthy controls. They also reported that hand function deterioration was associated with hand pain. Baron et al. [26] reported that age, coordination and hand strength were related to functional loss but not the the degree of OA. They suggested that, HOA does not contribute significantly to the objective functional decline in the elderly but may contribute to a subjective sense of functional limitation. Recently Felljstan et al. [27] investigated whether presence of inflammation in interphalangeal joints or thumb-base affects hand functions and

reported that global hand pain, reduced physical function and lower grip strength only associated with thumb – base involvement. Kodama et al. [28] demonstrated that loss of grip strength related with erosive HOA and radiographic disease severity. Similarly, a 2011 literature review mentioned a possible higher disease burden in erosive HOA and thumb – base involvement [24]. In our study in which we examined a specific subgroup of HOA, nonerosive interphalangeal OA without inflammatory changes and thumb-base involvement, strength and dexterity measurements were not affected when compared to the control group. Since thumb activity plays a major role in pinching, gripping and performing tasks, sparing of thumb-base in HOA may be related with less deterioration in hand functions. Likewise, lack of inflammation and erosions may also be related with better functionality. Despite not reaching statistical significance, HAQ-DI and AUSCAN-PF scores were higher in HOA group. Both HAQ and AUSCAN have previously been reported to perform well in assessing disability in HOA [22]. With preserved objective tests, this alterations in self-reported functionality is compatible with Baron et al.'s²⁶ suggestion of subjective sense of functional limitation in HOA patients.

Clinical reflection of both radiographic and ultrasonographic findings in HOA were previously investigated. Botha-Scheepers et al. [8] evaluated disease progression in 172 HOA patients in a two-year period and demonstrated that while functional loss and pain levels progressed in 50% of the patients, only 20% of the patients were progressed radiographically. There was a association between progression of pain and functional loss, yet radiological progression was not associated with changes in self-reported pain and function. Similarly Bijsterbosch et al. [7] investigated the long-term clinical and radiographic disease course of hand osteoarthritis. They found clinical and radiographic progression but clinical change and radiographic progression were not related. Contradictory to these findings association between radiographic severity and reduced grip and pinch strength were also reported [4, 28].

Relations between ultrasound findings and hand functions were also evaluated in several studies. Keen et al. [16] reported no correlation between US findings and clinical symptoms. Koutroumpas et al. [13] demonstrated that joint counts for bony swelling, tenderness, and inflammation detected in physical examination all correlated with functional status but no correlation was found with US joint count. On the contrary Kortekaas et al. [15] reported that osteophytes and joint space narrowing detected with US were independently associated with pain in individual HOA joints. In our study, we particularly evaluated osteophyte formations in interphalangeal joints both by radiography and ultrasound, and

searched for their effects on hand functions. US is reported to be more sensitive in detecting osteophytes than radiography and seems to be more advantageous in early diagnosis of HOA [29]. Similarly, in our study, US detected more osteophytes suggesting increased sensitivity when compared to radiography. However, none of the US-obtained osteophyte scores showed any significant correlation with strength and dexterity measurements. Likewise osteophyte scores obtained by radiography showed no correlation with strength measurements, on the other hand total osteophyte scores and total number of joints with osteophytes had a significant negative correlation with assembly part of dexterity testing. These findings suggest osteophyte formations prominent enough to be detected by radiography may partially alter dexterity.

Our study has several limitations. In order to examine a well defined, more specific subgroup of HOA we excluded patients with erosions, inflammation and thumb-base OA. We also excluded patients over the age of 65 to avoid confounding effects of senility on strength and dexterity. These measures may have unintentionally caused enrollment of relatively less severe cases of HOA. In addition, although no clinically meaningful differences observed in strength and dexterity measurements between groups, marked differences observed in HAQ-DI and AUSCAN-PF scores did not reach statistical significance, probably due to our small sample size.

Conclusions

In our study, no significant difference observed in hand strength and dexterity in nonerosive interphalangeal HOA patients without signs of inflammation when compared to healthy subjects. Osteophyte formations detected by US showed no correlation with any objective functional deterioration, while radiographically detected osteophytes may have a negative effect on hand dexterity.

Abbreviations

ACR: American College of Rheumatology; AUSCAN-PF: Australian Canadian Osteoarthritis Hand Index - physical function subscale; BMI: Body mass index; DIP: Distal interphalangeal; HAQ-DI: Health Assessment Questionnaire Disability Index; HOA: Hand osteoarthritis; IP: Interphalangeal; PIP: Proximal interphalangeal; US: Ultrasound; VAS: Visual analogue scale

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Authors' contributions

All authors declare that they have all participated in the design, execution, and analysis of the paper, and approved the final version.

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Availability of data and materials

The datasets used in this study are available from the corresponding author on valid request.

Ethics approval and consent to participate

The study protocol was approved by the institutional committee on Human Research Ethics.

Consent for publication

A written informed consent to participate and consent to publish was obtained from all subjects included in this study.

Competing interests

Authors declare no conflicts of interest.

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