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GRIP STRENGTH AND THE RISK OF DEVELOPING RADIOGRAPHIC HAND OSTEOARTHRITIS

Results from the Framingham Study

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Objective. **In knees, quadriceps strength may protect against osteoarthritis (OA). Muscle activity is a major determinant of forces at the hand joints, and grip is a common task during which high muscle forces are sustained, especially at the proximal hand joints (metacarpophalangeal [MCP] joints and thumb base). This longitudinal study of radiographic hand OA examined the association between incident OA at different hand joints and maximal grip strength.**

Methods. **Four hand joint groups were studied: distal interphalangeal (DIP), proximal interphalangeal (PIP), MCP, and the base of the thumb (carpometacarpal and scaphotrapezial combined). Subjects were members of the Framingham OA Study who had a baseline radiograph in 1967–1969 and a followup radiograph in 1992–1993 (mean followup 24 years) and had no prevalent radiographic OA in any hand joint at baseline. Incident disease was defined as development of OA defined as a modified Kellgren/Lawrence grade of ≥2. Grip strength was measured in kilograms by dynamometer in 1958–1961 and again in 1960–1963, and the 2 measures were averaged and divided into sex-specific tertiles. Joint-based analysis was performed by adjusting for age, physical activity, and occupational category using the lowest grip strength tertile as the referent.**

Results. **Baseline and followup radiographs were obtained from 746 subjects. Of these, 453 subjects with no prevalent OA at baseline were eligible for analysis. In men, higher maximal grip strength was associated with an increased risk of OA in the PIP (highest tertile odds ratio [OR] 2.8 compared with lowest tertile, 95% confidence interval [95% CI] 1.2–6.7), MCP (highest tertile OR 2.9, 95% CI 1.1–7.4), and thumb base joints (highest tertile OR 2.8, 95% CI 1.1–7.4). In women, there was increased risk of OA in the MCP joints (highest tertile OR 2.7, 95% CI 1.1–6.4).**

Conclusion. **Men with high maximal grip strength are at increased risk for the development of OA in the PIP, MCP, and thumb base joints, and women, in the MCP joints. No association was found between maximal grip strength and incident OA in the DIP joints of men or women.**

The relationship between muscle activity and joint load is complex. In cross-sectional studies, the hip abductor and quadriceps muscles are weaker in those with hip or knee osteoarthritis (OA), respectively, than in those without OA (1,2). These findings are consistent with results of biomechanical studies that demonstrate that muscle often serves to attenuate joint load (3). However, even at the hip or knee, certain patterns of muscle activity may result in increased joint load (4–7). Such patterns on a regular basis could theoretically contribute to the development and progression of OA. The relationship between muscle activity and joint load in the hand is made more complex by the numbers of muscles, soft tissue restraints, and joints involved even in simple, daily tasks. Furthermore, unlike muscles in the

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knees and hips, muscles in the hand do not act to decelerate the force of weight bearing.

Muscle activity is the major determinant of forces at the hand joints (8), and grip is one common task during which high muscle forces are sustained at certain hand joints (8,9). It is likely that the pathogenesis of hand OA relates both to forces at the joint and to the frequency with which those forces are applied. Direct measurement of joint forces is not feasible in a large-scale study. The measurement of maximal grip strength provides a global measure of the magnitude of muscle force that can be generated during a common activity.

Currently, little is known about risk factors that contribute to hand OA. It is believed that many factors increase the risk of OA, including biomechanical, genetic, and hormonal factors. To date, most studies of hand OA have been cross-sectional and few risk factors have been identified (10–13) other than sex, inheritance (14), and possibly injury (15). Whether risk factors for OA differ between specific hand joint groups has not previously been evaluated.

Studies of hand biomechanics demonstrate that forces generated at the distal interphalangeal (DIP) joints during grip are substantially less than those at proximal interphalangeal (PIP), metacarpophalangeal (MCP), and carpometacarpal (CMC) joints (9,16,17). To date, no studies have evaluated the association between maximal grip strength and the development of OA in the different hand joints.

We took advantage of the availability of longitudinal hand radiographs from a population-based group of individuals in the Framingham Study to evaluate the relationship between maximal grip strength and the development of hand OA. We also evaluated whether the relationship of maximal grip strength to hand OA differs by joint group.

PATIENTS AND METHODS

Subjects. Study subjects were members of the Framingham cohort, which is a population-based group of individuals who have been seen biennially since 1948 with the primary goal of longitudinally evaluating risk factors for cardiovascular disease. In 1967–1969, as part of an osteoporosis study conducted during biennial examinations 10 and 11, a baseline radiograph of the right hand was obtained. A followup radiograph of both hands (with exposures performed on each hand) was obtained in 1992–1993 (biennial examination 22), roughly 24 years later, as part of an OA study. Posteroanterior hand radiographs were taken using the same techniques, with the technician centering the central ray on the third MCP joint, at both baseline and followup visits. Home or nursing home visits were provided for those subjects who could not attend clinic at followup. The same techniques were used whether examination 22 was conducted at a clinic or as a home visit. Hand pain was not queried.

Maximal grip strength, in kilograms, was assessed in Framingham subjects at biennial examinations 5 (1957–1959), 6 (1958–1961), and 7 (1960–1963) using an adjustable, hand-held dynamometer. Subjects held the dynamometer in the position they found most comfortable. One grip strength measurement was obtained for each hand at each examination.

Radiograph readings. Baseline and followup radiographs were read in a paired manner by 1 of 2 experienced, academically based bone and joint radiologists. Each joint was graded for the presence of osteophytes, joint space narrowing, sclerosis, and cysts according to a modified Kellgren/Lawrence (K/L) scale (range 0–4). As we have previously reported, the modification allowed for a joint to be scored as having definite OA (grade 2 or higher) based on the presence of joint space narrowing alone, in the absence of osteophytes (18). Inter- and intraobserver reliability in reading radiographs and between the modified and traditional K/L scales was high (18).

Definition of variables. We restricted our evaluation to subjects with no radiographic hand OA in any hand joint at baseline (i.e., no hand joint with K/L score $\geq$2), and we focused on the right hand only because the left was not evaluated by radiography at baseline. We defined incident OA in a hand joint as the development of a K/L grade $\geq$2 in that joint. We examined 4 different joint groups in the hand: 4 DIP joints, 4 PIP joints, 4 MCP joints (excluding the thumb MCP), and base of thumb (scaphotrapezial and CMC combined). The thumb MCP and interphalangeal joints were not included.

We averaged maximal grip strength in the right hand over biennial examinations 6 and 7. If a subject did not have maximal grip measured at either of those examinations, we used grip strength information from examination 5 ($n = 2$).

Other variables. At biennial examination 12 (1971–1973), subjects were asked about the number of hours spent daily at various physical activities. The 24-hour sum of the number of daily hours at the different activity levels based on energy expenditure was weighted and summed using the method described by Kannel and Sorlie (19). This physical activity index has been found to correlate with risk of heart disease (19–21). Subjects' usual occupational status was broadly divided into 8 categories (professional, executive, supervisor, technical, laborer, clerical, sales, and housewife) using the Dictionary of Occupational Titles. Height and weight were measured at each Framingham examination, and body mass index was calculated as weight in kilograms at the current examination, divided by height in meters squared at examination 1.

Statistical analysis. We focused our analysis on the risk of developing hand OA according to earlier grip strength status. All analyses were sex specific because of the marked differences in both grip strength and OA incidence by sex. Grip strength was divided into sex-specific tertiles; the lowest grip strength tertile served as the referent group.

We first looked at the crude cumulative incidence of hand OA over the 24-year followup period for each joint group (i.e., DIP, PIP, etc.). We then calculated the risk of incident hand OA in the 4 different groups of hand joints (DIP, PIP, MCP, and base of thumb joint groups) over the followup period for each tertile of maximal grip strength. To assess the

Table 1. Baseline characteristics of study participants and Framingham subjects with baseline hand films*

	Participants (no prevalent OA)		Subjects with baseline and followup radiographs		Subjects with baseline radiographs	
	Men (n = 173)	Women (n = 280)	Men (n = 254)	Women (n = 492)	Men (n = 1,063)	Women (n = 1,484)
Age, mean ± SD years	54 ± 5	53 ± 5	55 ± 5	56 ± 6	61 ± 8	61 ± 8
Physical activity index, mean ± SD	36 ± 5	34 ± 4	35 ± 5	33 ± 4	34 ± 6†	32 ± 34‡
Maximal grip strength, mean ± SD	49 ± 7	26 ± 5	49 ± 8	26 ± 5	45 ± 8	25 ± 5
Grip strength range, kg	32.5–67	12–40.5	32.5–67	12–41	8–72	6.5–41
Job category, %						
Professional/executive	17	5	16	6	13	5
Supervisor	24	3	22	4	27	3
Technical	8	<1	10	1	12	1
Laborer	35	9	38	10	35	12
Clerical	5	9	4	8	4	8
Sales	8	<1	7	1	7	1
Housewife	NA	71	NA	68	NA	67
Job unknown	2	1	2	2	3	3

*OA = osteoarthritis; NA = not applicable.
† n = 889.
‡ n = 1,274.

effect of maximal grip strength on the risk of hand OA, we performed joint-based analysis by using the generalized estimating equation (GEE) method (22,23). This method, using each joint as the unit of analysis but accounting for the correlation between multiple joints in an individual, produces valid estimates of association between exposure and disease. All GEE analyses were adjusted for age and physical activity index as continuous variables. We adjusted for job category using professional/executive categories combined as the referent group; dummy variables were created for each of the remaining 6 job categories. A test for trend was done using the grip strength tertiles as an ordinal variable. We performed additional person-specific analyses by characterizing OA in a joint group if any of the 4 joints in that group had OA, and found that this approach had no effect on the results reported herein. Initial analyses included body mass index as a covariate, but it was excluded from the final models since it was not associated with the outcome.

RESULTS

At the baseline examination, 2,547 subjects obtained baseline hand radiographs. Seven hundred fifty-one subjects had repeat hand radiographs at the followup examination. Five individuals with known rheumatoid arthritis (RA) (use of second-line drugs and self-reported RA) were excluded from analysis. Of the 746 remaining subjects, 456 had no evidence of prevalent radiographic OA in any right hand joint at baseline. Three subjects had missing grip strength data and were therefore dropped from analysis, leaving 453 subjects eligible for our study.

Compared with all subjects who had a baseline film (n = 2,547), and compared with those who had baseline and followup films (n = 746), the 453 participants in this study were younger. The groups were similar in the percentage of women, maximal grip strength, and physical activity at baseline (Table 1).

When we examined the cumulative incidence of hand OA, we found that incident disease in multiple joints within a joint group was common in both men and women (Table 2). For example, among men, 33% developed incident OA in 1 DIP joint, 10% in 2 DIP joints, 9% in 3 DIP joints, and 5% in all 4 DIP joints. Women developed more incident disease in all joint groups with the exception of the MCP joints (14% of the women versus 21% of the men). No subject developed incident OA in more than 2 MCP joints.

Table 2. Cumulative incidence of radiographic hand osteoarthritis (OA) in each joint group in men and women*

Sex, joint group	% with no OA in joint	% with OA in 1 joint	% with OA in 2 joints	% with OA in 3 joints	% with OA in 4 joints
Men (n = 173)					
DIP	43	33	10	9	5
PIP	78	13	5	4	<1
MCP	79	17	4	0	0
Thumb base	74	26	NA	NA	NA
Women (n = 280)					
DIP	30	26	16	16	12
PIP	64	16	10	7	3
MCP	86	12	2	0	0
Thumb base	58	42	NA	NA	NA

* DIP = distal interphalangeal; PIP = proximal interphalangeal; MCP = metacarpophalangeal; NA = not applicable.

Table 3. Cumulative incidence of hand OA by grip strength tertile in 4 joint groups*

Sex, joint group	Grip low: No. affected/ total no. joints	Grip low: % affected	Grip middle: No. affected/ total no. joints	Grip middle: % affected	Grip high: No. affected/ total no. joints	Grip high: % affected
Men						
DIP	57/228	25	54/240	23	56/208	27
PIP	14/228	6	14/240	6	31/208	15
MCP	10/232	4	14/244	6	22/216	11
Thumb base	9/58	16	15/61	25	21/54	39
Women						
DIP	147/372	40	141/408	35	136/328	42
PIP	63/380	17	67/408	16	61/328	19
MCP	10/384	3	13/408	3	23/328	7
Thumb base	34/96	35	44/102	43	38/82	46

* See Table 2 for definitions.

We next evaluated whether the cumulative incidence of hand OA was affected by grip strength at baseline. Grip strength, in kilograms, was divided into tertiles for men (low 32.5–44.5; middle 45–52.5; high 53–67) and women (low 12–23.5; middle 24–27.5; high 28–40.5) separately. In the DIP joints, in both men and women, we found no association between maximal grip strength at baseline and the likelihood of developing hand OA at followup (Table 3). For example, among men whose maximal grip strength placed them in the lowest tertile, 25% of the DIP joints developed incident OA, whereas in the men with the highest grip strength, 27% of the DIP joints developed OA. However, in proximal joints, such as the MCPs, higher grip strength was associated with an increased risk of OA. Among men in the lowest grip strength tertile, only 10 MCP joints (4%) developed OA, whereas in the highest grip strength tertile, 22 MCP joints (11%) developed OA. This relationship was also strong for the thumb base (16% in lowest grip tertile versus 39% in highest tertile). In women, the relationship between maximal grip strength and the development of incident OA was similar, although not as strong (Table 3).

After adjusting for other factors that might affect the risk of OA (age, physical activity index, and occupation), we evaluated the overall risk of OA by grip strength tertile in the 4 different hand joint groups. At the DIP joints, maximal grip strength was not associated with the risk of development of OA in either men or women (Table 4). At the PIP joints, the risk of OA was increased among men in the highest tertile of grip strength (OR 2.8, 95% confidence interval [95% CI] 1.2–6.7). However, we found no similar association between grip strength and OA in the PIP joints in women.

At the MCP joint, we found an association between maximal grip strength and the development of OA in both men and women (Table 4). For example, among men in the highest tertile of grip strength, the risk of OA at the MCPs was significantly increased (OR 2.9, 95% CI 1.1–7.4). The risk was similarly increased in women in the highest tertile of grip strength (OR 2.7, 95% CI 1.1–6.4). Higher maximal grip strength was thus associated with higher risk of developing OA in the MCP joints (in men, $P < 0.05$ for trend, and in women, $P < 0.01$ for trend). We also found an increased risk of OA in the thumb base in men with higher maximal grip strength (Table 4). For example, among men in the highest tertile of grip strength, the OR for the development of OA in the thumb base was 2.8 (95% CI 1.1–7.4). Risk of OA in the thumb base in women with high grip strength was modestly increased and did not reach statistical significance.

Table 4. Adjusted odds ratios (OR) and 95% confidence intervals (95% CI) for risk of incident hand osteoarthritis by maximal grip strength tertile in men and women*

Sex, joint group	Grip low, referent	Grip middle OR	Grip middle 95% CI	Grip high OR	Grip high 95% CI
Men					
DIP	1.0	0.78	0.45–1.37	0.97	0.55–1.71
PIP	1.0	0.90	0.35–2.35	2.83	1.20–6.70
MCP	1.0	1.51	0.59–3.85	2.87	1.11–7.44
Thumb base	1.0	1.67	0.65–4.31	2.84	1.09–7.41
Women					
DIP	1.0	0.80	0.52–1.24	1.01	0.65–1.56
PIP	1.0	1.03	0.58–1.82	1.04	0.60–1.82
MCP	1.0	1.26	0.50–3.19	2.71	1.14–6.41
Thumb base	1.0	1.50	0.82–2.73	1.59	0.85–2.98

* Adjusted for age, occupational category, and physical activity index. See Table 2 for definitions.

DISCUSSION

In summary, in this first longitudinal analysis of the effect of maximal grip strength on the incidence or new occurrence of hand OA, we found that men with high maximal grip strength had an increased risk of OA in the PIP joints, MPC joints, and thumb base. For women, high maximal grip strength was associated with an increased risk of developing OA in the MCP joints and a modest increase in risk for OA in the thumb base. We found no association between maximal grip strength and incident OA in the DIP joints of either men or women.

The absence of a relationship between maximal grip strength and the development of OA in the DIP joint is not surprising, since maximal forces at this site are attained during pinching rather than grasping, which tends to load the proximal joints (16). An et al (9) demonstrated that the compressive force across the articular surface is much higher in the PIP and MCP joints than in the DIP joints during grasp, briefcase grip, holding a glass, or opening a jar. In grasp, compression forces have been shown to rise dramatically from the interphalangeal joint of the thumb to the first MCP to the first CMC joint (17). Compression forces as high as 120 kg may occur at the CMC during strong grasp (17). In a study of occupational hand OA by Hadler et al (24), subjects in the "winders" group (task involving a power grip) had significantly less DIP OA than did subjects in the "burlers" and "spinners" groups (tasks involving precision grip). Although the "winders" subjects did not have more OA in the CMC joints as assessed by radiographic score, "winders" did have decreased range of motion in the CMCs as compared with the other 2 groups (24). Consistent with our findings, Hochberg et al found no association between grip strength and prevalent DIP OA, after adjusting for age (10).

Studies that have examined only the pattern of hand use have not accounted for the forces generated during stereotypic occupational or other activity. Such forces are likely to vary between people, and may explain some of the variability in the incidence of hand OA within occupations. In other words, development of hand OA likely relates to not only the frequency of performing tasks that load the joint in question, but also the magnitude of force generated during the task.

A potential concern regarding this study is that grip strength is a mediating variable in the relationship between use pattern and incident OA, particularly since we used relatively simple measures to define occupational and physical activities. The crude occupational categories that we used, such as "sales" or "housewife," could contain subjects who had a wide range of hand activities. The physical activity index was devised to measure activity for cardiovascular purposes and does not account for specific hand use within an activity. However, previous studies have shown that anthropomorphic variables, rather than hand use, are the major determinants of grip strength, especially in the elderly. A study of 360 older persons showed that age, sex, hand circumference, and height were strongly associated with grip strength, but found no association between grip strength and either previous or current upper extremity activities at work or frequency of current manual activities (25). In another study, anthropometric factors, such as skeletal size, correlated more strongly with grip strength than did customary upper extremity activities or reported hand use (26).

The implications of the current study for treatment and prevention of hand OA are difficult to gauge. Our findings underline the complexity of the effects of muscle contraction forces on joints, which in some circumstances, may be beneficial and in others, potentially harmful. It is conceivable that appropriate hand strengthening may help prevent or even treat hand OA, since certain muscles also serve to attenuate load at the hand joints during specific activities (27).

We found a stronger effect of grip strength on OA risk in men than in women. It is well established that men have much higher grip strength (25,26,28), which could result in increased load across the articular surface, perhaps leading to joint damage. Thus, the stronger association of grip strength with hand OA in men is to be expected and further suggests that excessive muscle force may contribute to the pathogenesis of hand OA.

One limitation to our study was a large loss to followup, primarily due to the death of our quite elderly subjects. We have no way of knowing whether disease incidence was similar for subjects who did survive or did not attend followup. Another limitation is the lack of a standardized positioning for grip strength measurement in the early 1960s when the data were collected. Recent studies of arm and shoulder positioning and grip strength have been conflicting. One study demonstrated no difference in grip by arm position in the dominant hand (29), while another showed a difference of up to 4 kg in women and 7 kg in men (30). Yet another study concluded that grip measures from differing positions were very highly correlated, and position was not enough to cause a severe weakening of grip (31). Because we used average grip strength to rank our subjects into tertiles, it is unlikely that the lack of a standardized arm position would have affected our results. In comparing grip measures obtained 2 years apart, more than 90% of our subjects' repeat measures (examination 7) were within 5 kg of the previous measure (examination 6).

In conclusion, individuals with higher maximal grip strength are at increased risk for development of OA in certain hand joints. Our results, combined with those of others, are consistent with the possibility that OA in a given joint results from a complex interplay of factors including joint loading.

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Osteoarthritis of the thumb carpometacarpal joint in women and occupational risk factors : A case-control study

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Résumé / Abstract
Purpose: Among other etiologic factors involved in first carpometacarpal (CMC) osteoarthritis (OA), occupational factors have been postulated as influencing the occurrence of this condition. Very few epidemiologic studies, however, have evaluated this topic. Determining the occupational risk factors is important in proposing preventive measures at the workplace. This case-control study was undertaken to explore whether there was a history of greater exposure to some occupational factors (eg, occupations, hand postures, tasks involving the CMC joint) in women requiring surgery for CMC OA compared with women with no CMC OA noted by history and physical examination. Methods: The case subjects were 61 women surgically treated for primary CMC OA and the control subjects were 120 aged matched women without history or features of CMC OA. A detailed structured interview was developed to elicit information about age, smoking habits, medical history, lifestyle history, and occupational factors. Occupational factors were based on a detailed history of jobs, coded according to the International Standard Classification of Occupations. For the main occupation/job held for the longest duration and during an average working day, subjects were asked about hand posture or tasks involving requirements presumed to cause a strain or a high load to the CMC joint and about certain work conditions. Results: Of the 61 case and 120 control subjects, 5 and 14, respectively, had never worked. There was no difference between the average number of jobs through the working lifetime of the group of case subjects compared with the group of control subjects. Logistic regression analysis showed that after adjustment for age, smoking status, obesity, CMC OA family history, hysterectomy history, parity, and occasional job, the following occupational factors were risk factors for CMC OA: occupations presumed to be associated with increased risk for CMC OA, occupations involving repetitive thumb use, and jobs perceived by the subject having not enough rest breaks during a day. The group of case subjects had a higher prevalence of hysterectomy history and family CMC OA history compared with the group of control subjects. Conclusions: Although previous studies have reported that work and exposure history may lack precision as risk factors, our results give further evidence to support the role of certain occupational factors in the occurrence of CMC OA in women.

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CASE REPORT

Work-related bilateral osteoarthritis of the first carpometacarpal joints

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Background A 44-year-old industrial worker produced panels for folding doors for 9 years. During this period, he developed osteoarthritis (OA) of both first carpometacarpal joints. Surgery was performed without improvement.

Methods Clinical examination, demonstration and recording of work conditions, with photos and videos. The literature concerning first carpometacarpal OA was reviewed using PubMed.

Results The observation of work conditions demonstrated unusual forceful and repetitive ulnar flexion of both first fingers. No competing causes of OA could be identified.

Conclusion This patient had specific and intense work-related strain of both first carpometacarpal joints. A good temporal relation between work exposure and disease development was demonstrated and it appears likely that the OA was caused by work. However, there is very limited epidemiological evidence relating first carpometacarpal OA to work exposure.

Key words First carpometacarpal joint; osteoarthritis; repetitive forceful work.

Introduction

Osteoarthritis (OA) is perhaps the most common cause of disability in developed countries [1]. Primary degenerative disease of the hand and fingers as a clinical entity is usually considered multifactorial in pathogenesis. Several risk factors have been suggested, most importantly age, sex and body mass index (BMI; weight/m^2). More recently, genetic factors have attracted attention.

The prevalence of OA of the hand and fingers increases with age. Below the age of 40, <10% of individuals are affected against >70% of individuals over the age of 70 [2,3]. The same studies showed that first carpometacarpal OA followed the same age-related increase, but carpometacarpal OA lags behind interphalangeal OA by a decade although first carpometacarpal OA, when established, progresses faster.

A study of independent determinants of first carpometacarpal OA based on 639 hand radiographs obtained from the Ulm OA study, showed an OR of 1.8 (95% CI: 1.2–2.7) for female gender [4]. A similar but smaller effect for female gender was described in a study based on 3595 hand radiographs, OR 1.28 (95% CI: 1.08–1.53) [5].

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The impact of BMI on hand OA is a matter of dispute. The previously mentioned study showed no significant impact of BMI [4], while the other study showed an impact if BMI was 35 kg/m^2 or greater, OR being 1.98 (95% CI: 1.19–3.37) [5].

A genetic influence on OA was suggested in a study of 500 unselected female twins (130 identical and 120 unidentical) between 45 and 70 years of age who were screened radiologically for OA of the hands and knees [6]. The study suggested that genetic influence is between 39 and 65%. Recently a genome scan for joint-specific hand OA susceptibility, based on the Framingham study, has pointed to a linkage region on chromosome 15 for OA of the first carpometacarpal joint [7].

The overall prevalence of OA of the first carpometacarpal joint varies. The most commonly used method of assessment is by hand radiograph using the Kellgren and Lawrence score (K–L score) [8]. However, a recent study found that up to 15% of cases among men and 20% among women could not be classified by the K–L score [9]. The study found a prevalence of K–L grade ≥2 to be 4% in males and 7% in females. By comparison, a Finnish study found a prevalence of 4% in men and 9% in women [5]. A literature review on occupational use of precision grip and forceful gripping, and OA of finger joints found a somewhat higher prevalence, namely, 10% for males and 16% for females [10].

The impact of occupational exposure on OA is controversial. However, in Denmark, the National Board of Industrial Injuries has recently recognized OA of the hip and knee as occupational diseases under certain circumstances [11].

Long-term repetitive and stereotyped manual tasks have been related to different patterns of hand OA according to task. Interphalangeal OA was related to fine repetitive movements while first carpometacarpal OA was related to power grips [12]. In a cross-sectional survey, 1394 physicians recruited the two first patients consulting them for OA of the hip, knee or hand. The patients were given a questionnaire concerning their occupation and occupational exposure e.g. lifting, vibrating tools, repetitive movements, uncomfortable positions and pace. In women, repetitive movements and pace were associated with hand OA, OR 3.6 (95% CI: 2.4–5.7), while no definite association was seen in men [13]. A German survey found no association between heavy physical exertion in the workplace and OA of the first carpometacarpal joint [4]. Two cases of OA of the first carpometacarpal joint, which bear some resemblance to the case presented here, have been reported among Swedish carpenters [14].

The case of a 44-year-old male industrial worker, who developed bilateral OA of the first carpometacarpal joints, after 9 years of producing folding doors, is reported here. Demonstration and recording of work conditions were carried out and a literature search was performed.

Case report

The factory in which the patient was employed is a subdivision of a larger company and has ~100 employees, mostly men. It manufactures various building components, among them folding doors for use in agricultural and industrial constructions. The folding doors are made of individual panels, either aluminium or steel plates with a layer of polyurethane foam between them. The panels are hinged together, making a very flexible folding door.

The panels were produced one at a time on a large chest high table. Metal plates, either aluminium or steel, each of them between 4 and 8 m long and all 60 cm wide, were placed on the table. On the long sides, the panels were fitted by hand with plastic mouldings. The mouldings were made of semi-hard plastic, ~3 cm wide. The edges bend at 90 degrees and are fitted with small hooks, that were supposed to grab the bend edges of the panels. The patient would achieve this by applying pressure with both thumbs on the moulding, until the hooks would snap into their fittings. This required powerful grip, pressing both thumbs in ulnar flexion, while achieving counter pressure with the rest of the fingers (Figure 1). The patient would move his hands a few centimetres between each grip, gradually working his way along the edge, until he reached the end of the moulding.

The panels would require mouldings both at the top and bottom, making the total length of plastic moulding between 8 and 16 m for each panel. The patient would make 20 panels a day, on busy days up to 30, and 80% of the panels were 8 m long. This meant that the total length of mouldings to be fitted on 1 day could amount to something between 320 and 480 m. During the final year of his employment, the patient would use a small hammer to fit the mouldings, due to the growing disability and pain in his hands.

When the patient had fitted the mouldings, he would fill the space between the plates with polyurethane foam. The spraying head was made of a simple piece of pipe. Between each panel production, this piece of pipe had to be cleaned in a rather unorthodox way, using a simple electric drill and a pair of pliers (Figure 2). This would require a powerful grip with both hands while pressing the power button on the drill with the left thumb.

The patient was a 44-year-old male Caucasian, who had been employed for 9 years producing the folding doors. Previously, he had worked in non-manual work. He was physically fit, and had been a judo instructor and coach. He was right handed and had no previous history of hand trauma. There was no predisposition for OA in his family.

After 5 years of making panels, he developed pain at the base of his left thumb, especially when applying pressure or gripping. The pain worsened and became constant. Furthermore, he developed trigger fingers in the third and fourth fingers of the same hand. After consulting his general practitioner, radiology of the left hand and first carpometacarpal joint was performed, showing severe narrowing of the joint space and subluxation of the first carpometacarpal joint and severe OA was diagnosed. The patient continued to attend his job, and there were no alterations in the workplace. The following year, he developed similar symptoms on the right side with pain at the base of the thumb and trigger fingers in exactly the same positions as on the left side. Radiographs of the right hand showed changes identical to those previously seen on the left side. Because of his pain, the patient used a hammer when fitting the mouldings during the last year of his employment. He suggested other major changes in the work process, and the cleaning of the spraying head was automated. For this reason his function at work was changed, almost removed, and the company, no longer having use for him, laid him off.

An orthopaedic surgeon found bilateral OA of the first carpometacarpal joints and trigger fingers on the third and fourth fingers on both sides. The trigger fingers were treated with steroid injections and in September 2004 surgery was performed on the left first carpometacarpal joint with a resection–interposition arthroplasty a.m. Weilby. In May 2005, the same surgery was performed on the right side. However, the outcome was poorer than

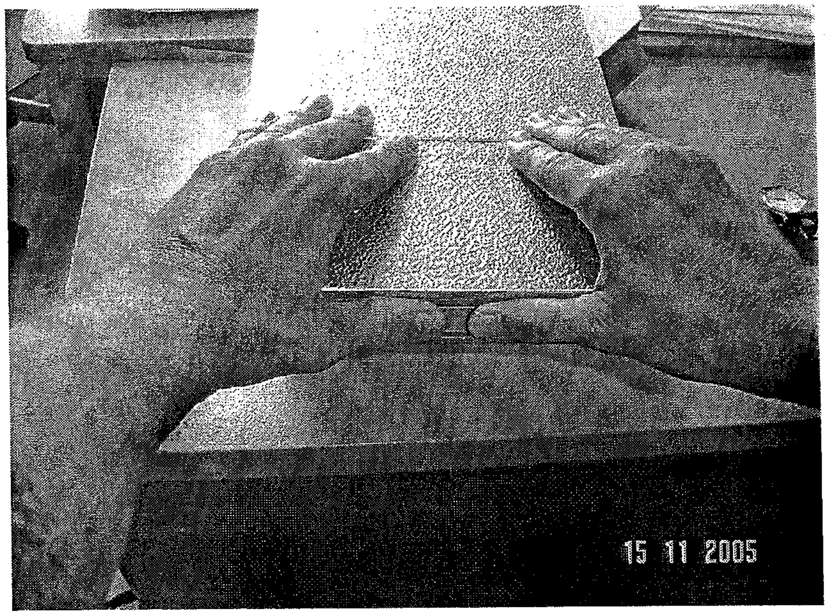

Figure 1. Patient demonstrating power grip while pressing the moulding into the panel section.

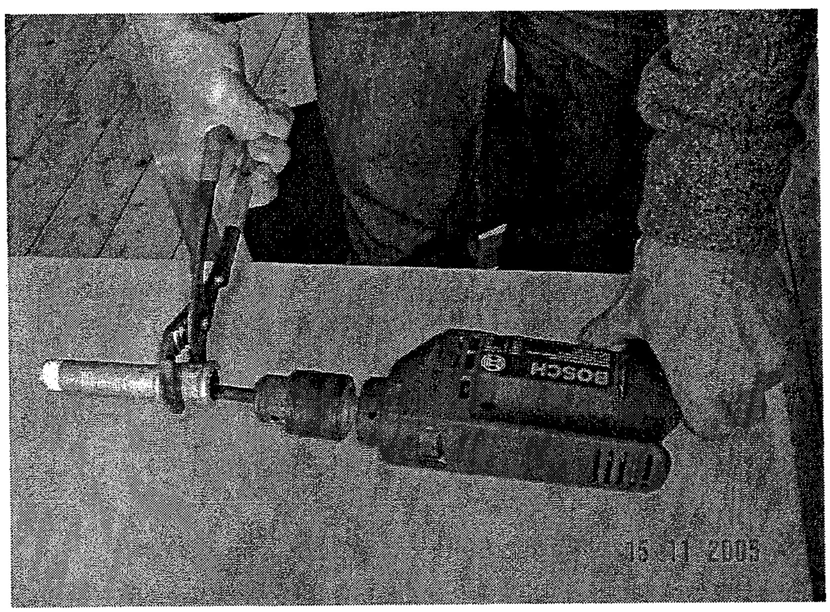

Figure 2. Patient demonstrating how he cleaned the sprayer head.

expected and the patient could no longer perform manual work that required any force.

By the time he was referred to the Department of Occupational Medicine, Vejle County Hospital, he had been on sick leave for 5 months. The right hand was still covered in a bandage at the initial examination in June 2005. On the left side, tenderness was found at the first carpometacarpal joint, and left hand grip force was measured to 5 kPa using a Martin vigorimetre. At the next examination in November 2005, the patient complained of nightly pain, and was unable to use a knife to cut meat and bread. There was tenderness at both first carpometacarpal joints, and grip force was reduced to 5 kPa on the left side and could not be measured on the right side. Radial flexion at the right wrist was reduced to 0 degrees.

Since the patient had lost contact with the workplace, and the work process had been changed, we were not able to obtain access to the workplace to perform exposure measurements. We therefore had to rely on the patient demonstrating his work task at the department. Digital photos and video recordings were made of this demonstration, using original materials and tools from the factory. As the patient had undergone surgery and suffered from weakness over the first carpometacarpal joint, no good estimate of task-related force could be obtained.

The department cooperated with the county social welfare office to help the patient get a job as a salesman, dealing in shop inventory.

Discussion

While OA of the first carpometacarpal joint is a common disease, bilateral OA in a 40-year-old male is uncommon. In this case, the exposure was rather unusual too. Unfortunately, it was not possible to obtain any good measurements of the force used by the patient, partly because the work process had been changed and the patient had no contact with the workplace and partly because he had undergone surgery that had radically changed his hand grip force. Obtaining good exposure measurements is often one of the greatest challenges in occupational medicine. It is also a major limitation in most of the studies that have tried to link work exposure to OA of the first carpometacarpal joint. Most studies are cross sectional, and rely on study groups referred because of the illness [13], with a resulting risk of overestimation of the problem. Other studies are based on job categories which makes it difficult to compare studies and questionnaires that might lead to overreporting and overestimation.

Attempts have been made to do more precise exposure measurements. Hadler *et al.* [12] had tasks described by a consulting industrial engineer and ergonomicist, although micromotion analysis was not performed. In the Danish PRIM study which deals with physical exposure assessments in monotonous repetitive work, 103 exposure groups were formed, and task-related exposures were quantified by 43 single exposure items using real-time video-based observation. This allowed computerized estimates of repetitiveness, body postures, force and velocity [15]. The PRIM study dealt only with tendinitis, epicondylitis and carpal tunnel syndrome and did not include OA. If a similar prospective study should be made on OA, the follow-up time would probably also have to be much longer since OA develops over decades.

A direct method of measuring forces applied by the thumb could be to use a pin gauge. A rather sophisticated method used in a study of thumb pain in physiotherapists, involved radiographs and a B & L pin gauge for testing strength. The hands were placed on a radiograph cassette and thumb pressure was applied on the pin gauge. In this way, the force applied could be measured and the joint movements including radial subluxation in the first carpometacarpal joint could be seen and measured simultaneously on the radiographs [16]. Forces up to 27.2 kg were measured.

It has been suggested that systemic factors such as sex, age and genetics may determine cartilage properties, but that local biomechanical factors, such as joint loading may determine the site and severity of OA [5].

In the presented case, stiffness of the plastic mouldings and the fact that they had hooks that had to be fitted into slots on the panels required significant pressure. The slippery surfaces of the metal panels made the patients fingers slide, most likely forcing him to increase thumb pressure. The patient had repetitively used forceful grip. The grip was not unusual in its character, but perhaps extraordinary by its repetitive, stereotyped nature. The patient had specific and intense work-related strain on both first carpometacarpal joints. A good temporal relation between work exposure and disease development existed. Thus, it is probable that work exposure played a major role in development of OA in this patient.

Because of the limited epidemiological evidence concerning first carpometacarpal OA and work exposure, there is need for further research including occupational measurements and dose–response relationships.

Conflicts of interest

None declared.

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