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Original Article

Survey of Osteoarthritis of the Shoulder in Patients who Underwent Knee Arthroplasty for Knee Osteoarthritis

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The relationship between osteoarthritis (OA) of the lower extremity and shoulder OA has not been established. This study evaluated the prevalence of shoulder OA in patients with knee OA. We collected contrast-enhanced computed tomography (CECT) images of the shoulder joints of 105 patients with knee OA that were taken 1 week after they underwent primary knee arthroplasty to check for venous thromboembolism (VTE). The images were compared with CECT images of 110 control-group patients that were taken for the purpose of differentiating VTE. Shoulder OA was present in a significantly higher percentage of patients with knee arthroplasty than controls (29% versus 15%), and the difference was particularly pronounced in patients in their 70s (33%) compared to age-matched controls (11%). Patients with knee OA often use arm support to stand up or walk due to knee joint pain and muscle weakness, which places the weight-bearing shoulder at risk of developing OA.

Key words: shoulder osteoarthritis, knee osteoarthritis, weight-bearing shoulder, knee arthroplasty

Osteoarthritis (OA) is a chronic degenerative disease of articular cartilage and other joint components, and is a common disease that affects many middle-aged and older adults [1,2]. OA is a multifactorial disease, and causes include systemic factors such as aging, gender, race, obesity, and genes, as well as local factors such as joint instability and mechanical stress following trauma or congenital abnormalities in joint morphology [1,2]. Therefore, OA is common in weight-bearing joints such as the spine, knee and hip joints, and there have been many examinations of relationships between weight-bearing joints, such as hip – spine syndrome [3] and coxitis knee [4]. Many study have focused on the above-named etiological factors [5-7]. On the other hand, there are few reports on the relationship between the shoulder joint and the joints of the lower limb. However, in our clinic we have noticed that patients with OA of the lower limbs, such as hip or knee joint OA, sometimes use their upper limb for support during standing or walking to offset knee pain and instability, placing a load on the shoulder joint. Therefore, in a previous report we investigated the association between shoulder OA and hip OA [8]. We found that the prevalence of shoulder OA was indeed significantly higher in patients with hip OA. In the present study, we hypothesized that patients with knee OA would also have a high prevalence of shoulder OA. To investigate this potential association, we used contrast-enhanced computed tomography (CECT) images of patients taken 1 week after knee arthroplasty, which are routinely used in our department to identify venous thromboembolism (VTE).

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Materials and Methods

This study was approved by the Ethics Committee of our institution (approval number 3802), which waived the need for informed consent due to the retrospective design. The shoulder joints from the CECT images of 105 patients (knee OA group; 26 men and 79 women; mean age, 73.3 [±7.7] years) taken in our department 1 week after their primary knee arthroplasty for knee OA from January to December 2019 were examined. They were compared with the CECT images of 110 controls (52 men and 58 women; mean age, 70.9 [±11.2] years) that were taken in the same period in other, non-orthopedic departments at our hospital to check for VTE. All CECT images were taken with a slice thickness of 2 mm. Cases in which the entire humeral head and glenoid fossa of the scapula were not included in the imaging area were excluded. Regardless of the presence or absence of clinical symptoms of shoulder joints, clear findings of osteophytes on the humeral head or glenoid fossa of the scapula or glenohumeral joint narrowing were analyzed as shoulder OA on axial CT images (Fig. 1). The prevalence of shoulder OA was compared with that of controls by age group, and differences in prevalence by sex and body mass index (BMI) were compared with those of controls. The cut-off value for BMI was set at 25 kg/m^2, which is generally regarded as the borderline of obesity. Patients were classified as having a BMI of <25 kg/m^2 or ≥ 25 kg/m^2. The proportions of right shoulder, left shoulder, and bilateral shoulder OA cases were also compared with those of the control group. In addition, we compared the prevalence of shoulder OA between patients who underwent medial unicompartmental knee arthroplasty (UKA) and patients who underwent total knee arthroplasty (TKA). In our department, medial UKA is indicated for medial osteoarthritis of the knee in which there is no obvious degeneration of the lateral compartment or patellofemoral joint and the varus deformity can be corrected. In the knee OA group, we also compared the difference in prevalence of shoulder OA with and without the use of walking aids. Patients with Kellgren-Lawrence grades 3-4 on the opposite knee at the time of knee arthroplasty and patients who had already undergone knee arthroplasty for the opposite knee were defined as having bilateral knee OA. We compared the prevalence of shoulder OA between patients with unilateral knee OA and those with bilateral knee OA. Disease duration of knee OA was classified as <5 years, 5-10 years, and ≥ 10 years when comparing the prevalence of shoulder OA. In patients with bilateral knee OA, disease duration was defined as the time from the onset of knee OA on the first side to the time of surgery. Chi-square and Fisher's exact tests were performed to analyze the statistical significance of the association between the above-named shoulder-OA-related parameters and prevalence of shoulder OA. The significance level was set at $p<0.05$. All statistical analyses were performed using IBM SPSS Statistics for Windows, version 23.0 (IBM Japan, Tokyo).

Results

Shoulder OA was significantly more common in the knee OA group than in the control group (29% (30/105) versus 15% (16/110)) (Chi-squared test, $p=0.012$). The difference was even more significant between knee OA patients and controls in their 70s: 33% (17/51) versus 11% (4/37), respectively (Fisher's exact test, $p=0.009$) (Table 1). In terms of sex, 12% (6/52) of males and 17% (10/58) of females in the control group had shoul-

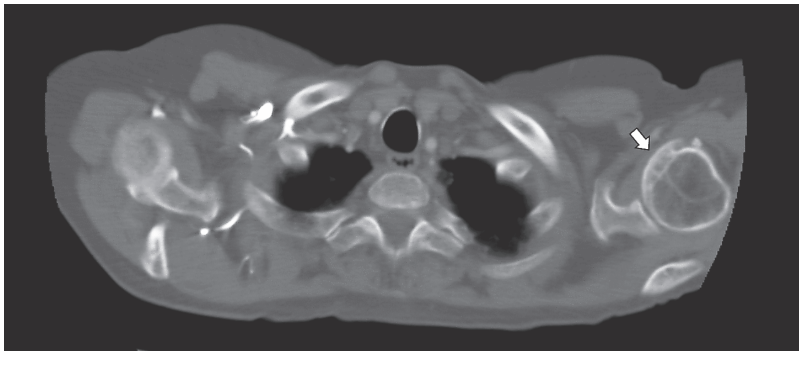

Fig. 1 Contrast-enhanced computed tomography axial view of the shoulder joint showing osteophytes (arrows) in the humeral head.

der OA, while 31% (8/26) of males and 28% (22/79) of females in the knee OA group had shoulder OA. Both prevalence rates were higher in the knee OA group, but the difference was not significant for either sex (both Fisher's exact test, $p > 0.05$) (Table 2). The average BMI was 23.7 kg/m^2 [±5.4] in the control group and 25.7 kg/m^2 [±4.1] in the knee OA group. Sixteen percent (12/75) of patients with a BMI of < 25 kg/m^2 and eleven percent (4/35) of patients with a BMI ≥ 25 kg/m^2 in the control group had shoulder OA. In contrast, 34% (16/47) of patients with a BMI of < 25 kg/m^2 and 24% (14/58) of patients with a BMI of ≥ 25 kg/m^2 in the knee OA group had shoulder OA. In patients with a BMI of < 25 kg/m^2, shoulder OA was significantly more common in the knee OA group (Chi-squared test, $p = 0.021$). Additionally, although there was no significant difference between the BMI groups, the prevalence of shoulder OA tended to be higher in those with a BMI of < 25 kg/m^2 than in those with a BMI of ≥ 25 kg/m^2 (Table 3). The proportions of right shoulder, left shoulder, and bilateral shoulder cases were 44% (7/16), 12% (2/16), 44% (7/16) in the control group and 30% (9/30), 13% (4/30), 57% (17/30) in the knee OA group. There was a trend toward a higher proportion of right-sided cases in the control group and a higher proportion of bilateral cases in the knee OA group, but these differences were not significant (Table 4). In the knee OA group, the prevalence of shoulder OA in patients undergoing UKA was 27% (13/49) and the prevalence of shoulder OA in patients undergoing TKA was 30% (17/56). The difference was not significant (Chi-squared test, $p > 0.05$). Also in the knee OA group, the comparison of prevalence rates according to the use or nonuse of walking aids showed that shoulder OA was present in 33% (17/51) of patients who used walking aids and 24% (13/54) of those who did not; although the prevalence tended to be higher with walking aid use, the difference was not significant (Chi-squared test, $p > 0.05$). Comparing unilateral and bilateral knee OA cases, shoulder OA prevalence tended to be higher in

Table 1 Comparison of the prevalence of shoulder OA between patients who underwent knee arthroplasty and age-matched controls by age group

Age (years)	Control group	Knee OA Group	*P*-value
Total	15% (16/110)	29% (30/105)	0.012
≤ 50s	0% (0/21)	0% (0/4)	1.000
60s	4% (1/23)	10% (3/29)	0.621
70s	11% (4/37)	33% (17/51)	0.009
≥ 80s	38% (11/29)	48% (10/21)	0.774

The rate of shoulder OA was significantly higher in knee OA patients than controls, particularly for patients in their 70s.
OA, osteoarthritis.

Table 2 Comparison of prevalence of OA according to sex

Sex	Control group	Knee OA Group	*P*-value
Male	12% (6/52)	31% (8/26)	0.058
Female	17% (10/58)	28% (22/79)	0.156

In both sexes, the prevalence of shoulder OA was higher among knee OA patients than controls; however, these differences were not significant.
OA, osteoarthritis.

Table 3 Comparison of prevalence of shoulder OA according to BMI

BMI	Control group	Knee OA Group	*P*-value
< 25 kg/m^2	16% (12/75)	34% (16/47)	0.021
≥ 25 kg/m^2	11% (4/35)	24% (14/58)	0.218
P-value	0.731	0.264	

In patients with a BMI of < 25 kg/m^2, shoulder OA was significantly more common in the knee OA group. In either group, there was a tendency for the prevalence of shoulder OA to be higher in those with a BMI of < 25 kg/m^2.
OA, osteoarthritis; BMI, body mass index.

Table 4 Prevalence of shoulder OA in the right, left, and both shoulders

Location	Control group (n = 16)	Knee OA (n = 30)	*P*-value
Right shoulder	44% (7)	30% (9)	0.517
Left shoulder	12% (2)	13% (4)	1.000
Bilateral shoulders	44% (7)	57% (17)	0.538

Shoulder OA was found on the right side in a large proportion of patients in the control group and bilaterally in a large proportion of patients in the knee OA group, but the difference was not significant.
OA, osteoarthritis.

bilateral than in unilateral cases (30% (24/71) versus 18% (6/34)), but not significantly so (Chi-squared test, $p > 0.05$). There was also a trend toward higher shoulder OA prevalence with increasing duration of knee OA: 24% (9/38) for < 5 years, 28% (7/25) for 5-10 years, and 33% (14/42) for ≥ 10 years, but no significant differences were found (Fisher's exact test, $p > 0.05$) (Table 5).

Discussion

In this study, 15% of the controls had shoulder OA. Their CECT scans were taken to check for VTE, rather than in response to shoulder symptoms. Kircher and colleagues stated that physical and radiographic findings do not always match in shoulder OA [9], and are less frequent in studies of symptomatic individuals than in studies of the general population [10, 11]. While there are scattered reports on the prevalence of knee and hip OA in the general population [12-14], to our knowledge there have been only two reports on the prevalence of shoulder OA in the general population [15, 16]. In Japan, Kobayashi and colleagues reported a prevalence of 17.4% for shoulder OA in 541 participants aged 40 years or older (mean 66.6 years) in a general population health examination [15]. In South Korea, Oh and colleagues studied the general population aged 65 years or older (mean 71.8 years) and reported a shoulder OA prevalence of 16.1% [16]. These findings were similar to the prevalence in the control group in this study, who underwent CECT for VTE differentiation purposes. Although the diagnosis of shoulder OA on CT axial images is not common, we believe it is reliable.

Regarding risk factors for shoulder OA, Oh and colleagues investigated the relationship between the prevalence of shoulder OA and age, gender, height, weight, BMI, knee OA, diabetes, hypertension, and smoking [16]. As a result, they reported that age and knee OA were the only independent risk factors for shoulder OA. Among their 255 participants who had knee OA, 60 (23.5%) exhibited accompanying shoulder OA. However, they did not analyzed that the mechanism by which knee OA confers a risk for shoulder OA in their study. There have been no other reports on the association between shoulder OA and knee OA. Knee extensor muscle strength is considered to play an important role in the act of standing [17]. In addition, it is well known that quadriceps femoris muscle strength declines with the onset of knee OA [18]. When the supportability of the knee joint decreases due to weakening of the quadriceps femoris muscle, it is considered that the load on the shoulder joint increases because the support of the upper limbs is required to stand up. On the other hand, Wing and colleagues coined the term "weight-bearing shoulder" to describe the shoulders of patients with disabilities of the lower limbs who use crutches or wheelchairs for locomotion [19]. Following Wing's introduction of the term, there have been scattered reports of weight-bearing shoulder as a cause of rotator cuff injuries and shoulder OA [20-

Table 5 Prevalence of shoulder OA by surgical procedure of knee arthroplasty, use of walking aids, unilateral or bilateral knee OA, and duration of knee OA

Variable	Shoulder OA present
Surgical procedure	
UKA	27% (13/49)
TKA	30% (17/56)
P-value	0.829
Use of walking aids	
Yes	33% (17/51)
No	24% (13/54)
P-value	0.388
Knee OA	
Unilateral	18% (6/34)
Bilateral	30% (24/71)
P-value	0.108
Disease duration	
< 5 years	24% (9/38)
5-10 years	28% (7/25)
≥ 10 years	33% (14/42)
P-value	0.633

The prevalence of shoulder OA was higher among patients who used walking aids and whom with bilateral knee OA; however, the differences were not significant.
OA, osteoarthritis; UKA, unicomparmental knee arthroplasty; TKA, total knee arthroplasty.

22]. We hypothesized that patients with knee OA have a condition similar to weight-bearing shoulder during standing or walking. In the present study, knee OA patients had a significantly higher prevalence of shoulder OA. Furthermore, a comparison of the control and knee OA group by age showed that the difference was greatest for patients in their 70s. This trend is similar to that reported previously for the hip joint [8].

Since the knee joint is a weight-bearing joint, knee OA has long been considered to be associated with BMI [12,23]. Conversely, a relationship between upper extremity joint OA and BMI has recently been described, and genetic involvement is considered to be a factor [24,25]. In fact, in our study mean BMI was higher in the knee OA group than in the control group, but both groups tended to have more shoulder joint OA in those with a BMI of < 25 kg/m^2. Oh and colleagues also reported that BMI was not a risk factor for shoulder OA, but knee OA was an independent risk factor for shoulder OA. In our present study, although the involvement of other OA disease-related genes could not be denied, the influence of knee OA on shoulder OA was stronger than the influence of BMI. Our control group had a higher rate of right-sided shoulder OA, and our knee OA group had a higher rate of bilateral shoulder OA. This trend was similar to that reported previously for the hip joints [8]. In addition, among the knee OA group, the prevalence of shoulder OA tended to be slightly higher in patients who used walking aids on a daily basis than in those who did not use such aids. Furthermore, bilateral knee OA patients were more likely to require more upper extremity support during standing and walking than unilateral knee OA patients, which may explain the higher incidence of shoulder OA. The prevalence of shoulder OA tended to increase with the duration of disease, but there was little difference between the UKA and TKA groups. This may be because the intensity of deformity does not necessarily correlate with the intensity of pain in OA [26], although our department applies TKA to patients with more severe deformity.

This study has several limitations. First, the number of cases observed was relatively small. With a larger number of cases, we might have uncovered significant differences between the use of walking aids or unilateral and bilateral knee OA, similar to our hip study. [8] Second, clinical findings of the shoulder joint, including pain or range of motion, were not obtained. Third, the CECT images were taken to investigate VTE, so the position of the shoulder joint was not consistent. Additionally, it has not been possible to distinguish between primary shoulder OA and secondary shoulder OA. Despite these limitations, our results suggest that the presence of knee OA promotes the development of shoulder OA. In regard to the surgical timing of knee arthroplasty for advanced knee OA, we believe that it should be performed before irreversible degeneration occurs in other weight-bearing joints such as the spine and hip joints, but we also believe that the risk of shoulder OA is high and attention should be paid to the shoulder joint.

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