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Original Article

Survey of Shoulder Osteoarthritis in Patients who Underwent Total Hip Arthroplasty for Hip Osteoarthritis

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To the best of our knowledge, no previous studies have reported a relationship between osteoarthritis (OA) of the lower limbs and OA of the shoulder joints. We evaluated the correlation between shoulder OA and hip OA. We collected contrast-enhanced computed tomography (CECT) images of the shoulder joints of 159 patients with hip OA who underwent primary total hip arthroplasty (THA). The images, taken 1 week after THA to monitor venous thromboembolism (VTE), were used to examine the prevalence of shoulder OA. They were compared with those of 103 controls who underwent CECT during the same period to monitor VTE. Shoulder OA was observed in 15% of the controls and 24% of the THA patients. Although the rate was somewhat higher in the THA group, the difference was not significant. However, in the THA group, significantly more patients with bilateral hip OA (33%) had shoulder OA than those with unilateral hip OA (17%). In summary, the prevalence of shoulder OA was significantly higher in patients with bilateral hip OA. In these patients, pain and instability in the hip joints require them to use arm support to stand up or walk, putting the weight-bearing shoulder at risk of developing OA.

Key words: shoulder osteoarthritis, hip osteoarthritis, weight-bearing shoulder, total hip arthroplasty

Osteoarthritis (OA) is a chronic degenerative disease of the cartilage, bones, and other components of the joints that affects many people in their middle and old age [1,2]. It is caused by multiple factors and may be affected by both systemic and localized factors. Systemic factors include aging, ethnicity, obesity, and genetics; localized factors include joint instability and mechanical stress on joints arising from traumatic or congenital deformations [1,2]. OA often affects weight-bearing joints such as the spine, hips, or knees, and the relationships between weight-bearing joints in conditions such as hip-spine syndrome [3] and coxitis knee [4] are well known, with many studies focusing on these factors [5-7]. However, to the best of our knowledge, no studies have yet investigated the relationship between the shoulder joint and joints of the lower limbs. We believe that pain and instability in lower limb joints, such as the hip or knee, would require individuals to support themselves with their upper limbs while standing up or walking. This, in turn, would inevitably transfer some of the load to the shoulder. Thus, we hypothesized that this load increase would cause shoulder OA. In our department, contrast-enhanced computed tomography (CECT) scans are performed routinely 1 week after total hip arthroplasty (THA) to monitor venous thromboembolism (VTE). We used those images to estimate the prevalence of shoulder OA in patients with hip OA.

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Materials and Methods

The present study was approved by the Kawasaki Medical School Ethics Committee (Approval No. 3802). The requirement for informed consent was waived by the ethics committee because of the retrospective nature of this study. The study was conducted in accordance with the Declaration of Helsinki.

We examined the CECT images of shoulder joints from 159 patients (14 men and 145 women; mean age, 66.7 [±9.2] years) taken at our department 1 week after primary THA for hip OA performed between January and December of 2018. These images were compared with those of 103 controls (49 men and 54 women; mean age, 70.3 [±11.9] years), whose CECT images were acquired in our department during the same period to check for VTE. All CECT images were taken at a slice thickness of 2 mm. Patients whose entire humeral head and scapula were not captured in the images were excluded. Irrespective of the clinical symptoms of shoulder OA, 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). Various age groups (≤50s, 60s, 70s, and ≥80s) of THA patients were compared with age-matched controls. Differences in the prevalence of shoulder OA were compared between THA patients and controls according to sex. Additionally, THA patients with unilateral (right or left) and bilateral shoulder OA were compared with controls. Furthermore, in the THA group, patients who used walking aids were compared with those who did not use walking aids to investigate any differences in the prevalence of shoulder OA. Patients with Kellgren-Lawrence grades 3-4 on the opposite hip at the time of THA and patients who had already undergone THA for the opposite hip were defined as having bilateral hip OA. The prevalence of shoulder OA was compared between patients with unilateral hip OA and bilateral hip OA. The disease duration of hip OA was classified as <5 years, 5-10 years, and ≥10 years to compare the prevalence of shoulder OA. In patients with bilateral hip OA, disease duration was defined as the time from the onset of hip OA on the first side to the time of surgery. Chi-square tests and Fisher's exact tests were performed to analyze the statistical significance of the associations between the said factors and the prevalence of shoulder OA. Additionally, in the THA group, Spearman's rank-correlation coefficient was used to analyze the correlation between the said factors and the 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, Ltd., Tokyo, Japan).

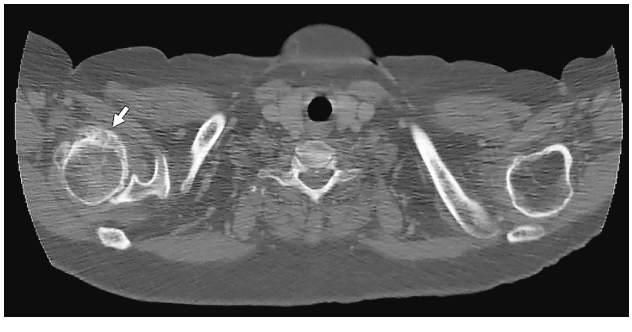

Fig. 1 The arrow shows an osteophyte on the humeral head in an axial image of a shoulder joint on contrast-enhanced computed tomography.

Results

Shoulder OA was observed in 15% (15/103) of the controls and 24% (38/159) of the patients who underwent THA. Although the rate was somewhat higher in the THA group, the difference was not significant (Chi-square test, $p>0.05$). Among patients in their 70s, 10% (3/30) of the controls and 40% (19/47) of the THA patients had shoulder OA; thus, THA patients had a significantly higher rate of shoulder OA than controls (Fisher's exact test, $p=0.004$) (Table 1). In terms of sex-specific differences, 12% (6/49) of men and 17% (9/54) of women in the control group had shoulder OA. In contrast, 50% (7/14) of men and 21% (31/145) of women in the THA group had shoulder OA. In both sexes, the prevalence of shoulder OA was higher among patients who had undergone THA; however, the difference was significant only for men (Fisher's exact test, $p=0.007$) (Table 2). Shoulder OA was observed in the right shoulder in 47% (7/15) of control subjects, in the left shoulder in 13% (2/15), and in both shoulders in 40% (6/15); and in the right shoulder in 21% (8/38) of THA subjects, in the left shoulder in 13% (5/38), and in both shoulders in 66% (25/38). Shoulder OA was more prevalent on the right side in the control group. In contrast, most patients in the THA group had bilateral shoulder OA. However, in both cases, the difference was not significant (Fisher's exact test, $p>0.05$) (Table

3). Furthermore, 33% (26/78) of THA patients who used walking aids and 15% (12/81) of those who did not had shoulder OA; a significantly high number of patients who used walking aids had shoulder OA (Chi-square test, $p=0.006$). Additionally, 17% (16/93) of patients with unilateral hip OA and 33% (22/66) with bilateral hip OA had shoulder OA; a significantly high number of patients with bilateral hip OA had shoulder OA (Chi-square test, $p=0.019$). In terms of the disease duration of hip OA, 25% (16/65) of those with hip OA for < 5 years also had shoulder OA, as did 20% (9/45) of those with hip OA for 5-10 years, and 27% (13/49) of those with hip OA for ≥ 10 years; however, the differences were not significant (Chi-square test, $p>0.05$) (Table 4). The use of walking aids was found to correlate with age (Spearman's rank-correlation coefficient = 0.26, $p=0.001$), while bilateral hip OA and age showed no correlation (Spearman's rank-correlation coefficient = −0.036, $p>0.05$) (Table 5).

Table 1 Comparison of the prevalence of shoulder osteoarthritis (OA) between patients who underwent total hip arthroplasty (THA) and age-matched controls according to age group

Age (years)	Control group	THA group	*P*-value
Total	15% (15/103)	24% (38/159)	0.066
≤ 50s	0% (0/21)	3% (1/36)	1.000
60s	4% (1/24)	19% (12/62)	0.100
70s	10% (3/30)	40% (19/47)	0.004
≥ 80s	39% (11/28)	43% (6/14)	0.82

THA patients had a significantly higher rate of shoulder OA in the 70s.
THA, total hip arthroplasty; OA, osteoarthritis.

Table 2 Prevalence of shoulder OA by sex

Sex	Control group	THA group	*P*-value
Male	12% (6/49)	50% (7/14)	0.007
Female	17% (9/54)	21% (31/145)	0.43

Between both sexes, the prevalence of shoulder OA was higher among THA patients; however, the difference was only significant for men.
THA, total hip arthroplasty; OA, osteoarthritis.

Table 3 Prevalence of shoulder OA in the right, left, and both shoulders

Location	Control group (n = 15)	THA group (n = 38)	*P*-value
Right shoulder	47% (7)	21% (8)	0.091
Left shoulder	13% (2)	13% (5)	1.000
Both shoulders	40% (6)	66% (25)	0.086

Shoulder OA was found on the right side in a large proportion of patients in the control group and bilaterally in a larger proportion of patients in the THA group, but the difference was not significant.
THA, total hip arthroplasty; OA, osteoarthritis.

Discussion

In this study, we observed shoulder OA in 15% of the controls. Their CECT images were checked for VTE, regardless of any symptoms in the shoulder joints. Kircher *et al.* have found that physical symptoms and radiographic findings of shoulder OA do not always match [8]. The prevalence of shoulder OA estimated in studies targeting symptomatic shoulder OA is lower than that reported in studies targeting the general population [9,10]. Several studies have surveyed the prevalence of hip or knee OA in the general population [11-13]; however, to the best of our knowledge, only

Table 4 Prevalence of shoulder OA according to the use of walking aids, unilateral or bilateral hip OA, and duration of hip OA

Variable	Shoulder OA present
Use of walking aids	
Yes	33% (26/78)
No	15% (12/81)
p-value	0.006
Hip OA	
Unilateral	17% (16/93)
Bilateral	33% (22/66)
p-value	0.019
Disease duration	
< 5 years	25% (16/65)
5–10 years	20% (9/45)
≥ 10 years	27% (13/49)
p-value	0.75

A significantly higher number of patients who used walking aids had shoulder OA.
Additionally, a significantly higher number of patients with bilateral hip OA had shoulder OA than those with unilateral hip OA.
OA, osteoarthritis.

Table 5 Spearman's rank-correlation coefficient of factors related to the prevalence of shoulder OA

	Age (years)	Unilateral hip OA = 0 Bilateral hip OA = 1	Walking aids (–) = 0 Walking aids (+) = 1
Age (years)	–	–0.036	0.26**
Unilateral hip OA = 0 Bilateral hip OA = 1	–	–	0.21**
Walking aids (–) = 0 Walking aids (+) = 1	–	–	–

*$p<0.05$, **$p<0.01$
The use of walking aids and age were correlated with each other, while bilaterarl hip OA and age were not.
OA, osteoarthritis.

two studies have explored the prevalence of shoulder OA in the general population [14, 15]. Kobayashi *et al.* report a prevalence of 17% (94/541) of shoulder OA in the health screening data of the general population aged 40 years and older (mean age, 66.6 years) in Japan [14]; Oh *et al.* found a prevalence of 16% (109/679) in a survey of the general population aged 65 years and older (mean age, 71.8 years) in South Korea [15]. These prevalence rates are very close to those found in our control group, whose CECT images were taken to check for VTE.

Oh *et al.* list knee OA as a significant risk factor for shoulder OA, with an odds ratio of 2.38 (95% confidence interval, 1.57-3.62) [15]. However, they did not analyze the details of the relationship between knee and shoulder OA. To the best of our knowledge, no other reports have examined the relationship between shoulder OA and lower limb OA. The prevalence of shoulder OA was higher in the THA group than in the control group in the present study. We believe that this difference could be attributed to pain and instability in the hip joints, which could have required patients to use their upper limbs for support when standing up or walking, thereby transferring some of the load to the shoulder joints. In 1983, Wing *et al.* proposed the notion of the "weight-bearing shoulder" with regard to the shoulder joints of patients with paraplegia [16]. They 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, since these patients often use their upper limbs, including the shoulder joints, to support their body weight. Bayley *et al.* reported that the internal pressure of the shoulder joint is increased by 2.5-fold during transfer into a wheelchair [17]. Since the proposal of the term "weight-bearing shoulder" by Wing and colleagues, some reports have mentioned that weight-bearing shoulder may cause rotator cuff injury or shoulder OA [18-20]. In patients with hip OA, we considered that the shoulders may function similarly to weight-bearing shoulders during standing up or walking with walking aids. Our comparison of THA patients with their age-matched controls revealed the greatest difference in people in their 70s. Age is a known risk factor for OA. Muscle strength also decreases as people age. We believe that the prevalence of shoulder OA increased significantly in hip OA patients as they entered their 70s because they required more upper body support for standing up or walking. The difference between THA patients and controls diminished as the prevalence of shoulder OA increased in the control group once they reached their 80s.

In regard to sex differences, men who underwent THA had a significantly higher prevalence of shoulder OA (50%, 7/14) than women who underwent THA (21%, 31/145). This may be attributed to the sex difference in pain thresholds, or to the fact that men have stronger muscles than women, which may explain why they depend more on upper muscle strength to stand up. The sample size of 14 was too small to make conclusive remarks about sex differences. However, the proportion of men in the THA group was smaller than that in the control group; if the proportions had been similar, the prevalence of shoulder OA in the THA group might have been even higher.

The control group had a higher rate of right shoulder OA, while the THA group had a higher rate of bilateral shoulder OA. Although we did not determine the dominant hand in each group, the control group might have had a higher prevalence of OA on the right shoulder because the right is commonly the dominant hand, whereas the rate of left shoulder OA was high in THA patients, in whom load was also applied to the left arm when standing up or walking. In the THA group, shoulder OA was significantly more prevalent in people who routinely used walking aids than in those who did not. Although shoulder OA was not necessarily on the side on which they used the walking aid, people requiring walking aids are likely to routinely face situations in daily life that require support with both upper limbs. Moreover, the rate of shoulder OA was significantly higher in those with bilateral hip OA because they too

likely require more upper limb support for standing up or walking than people with unilateral hip OA. In contrast, there were no differences in terms of the duration of hip OA. This demonstrates that although a long time may have passed since the onset of hip OA, hip OA alone would not lead to shoulder OA in the absence of load on the shoulder joints. Moreover, correlation analysis indicated that the use of walking aids and age were correlated, while bilateral hip OA and age were not. Thus, bilateral hip OA was considered an independent risk factor for shoulder OA.

There are several limitations to this study. First, the sample size was small and the male-female ratios between control group and THA group were different. Second, data on pain and other clinical findings related to shoulder OA were not obtained. Third, the shoulder joint position was not standardized on the CECT images, as the images were taken to check for VTE. Finally, the potential involvement of OA disease-related genes cannot be denied. However, the results of this study indicate that hip OA is associated with the onset of shoulder OA. We suggest that hip-spine syndrome and coxitis knee should be considered before performing THA for advanced hip OA, but THA should be performed before there is irreversible degeneration of the spine or knee. Patients with advanced hip OA may have irreversible changes not only in typical weight-bearing joints but also in the shoulder joints. It is therefore important to pay attention to the shoulder joint when examining patients with advanced hip OA.

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