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Impact of symptom bilaterality and hand dominance on patient-reported disability outcomes

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Abstract

Objectives: It is not clear if using patients with bilateral symptoms would impact the level of disability reported in orthopaedic research. The purposes of this study were to (1) examine the prevalence of bilateral shoulder symptoms (significant pain, stiffness or weakness affecting function) in patients with rotator cuff impingement syndrome, rotator cuff tear and osteoarthritis of the glenohumeral joint, (2) explore risk factors associated with bilateral shoulder symptoms, and (3) examine the impact of symptom bilaterality and hand dominance on pre- and post-operative patient-oriented disability outcomes.

Methods: This study involved secondary analysis of prospectively collected data of patients who had undergone shoulder surgery and had returned for their 1-year follow-up. Two outcome measures were collected prior to surgery and at 1-year following surgery: the American Shoulder and Elbow Surgeons and the Constant–Murley Score.

Results: Data of 772 patients, 376 (49%) females, 396 males (51%); 288 (impingement syndrome), 332 (rotator cuff tear), and 152 (osteoarthritis) were included in the analysis. There was a statistically significant difference in the prevalence of bilateral symptoms being 44%, 28%, and 22% in the osteoarthritis, impingement syndrome, and rotator cuff tear groups, respectively ($p < 0.0001$). The prevalence of dominant side involvement was 71%, 67%, and 53% in the rotator cuff tear, impingement syndrome, and osteoarthritis groups ($p < 0.0001$). Older age and female sex were risk factors for development of bilateral symptoms only in patients with rotator cuff tear. Neither symptom bilaterality nor dominant arm involvement had a negative impact on patient-oriented disability outcome measures prior to or after surgery ($p > 0.05$).

Conclusion: This study shows that patients with osteoarthritis of the glenohumeral joint have the highest prevalence of bilateral shoulder complaints. The older age and the female sex increased the risk of having bilateral symptoms in patients with rotator cuff tear. Having bilateral shoulder symptoms or dominant side involvement was not associated with higher level of disability prior or after surgery.

Keywords

Bilateral, shoulder pathology, hand dominance

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Introduction

In the field of surgical outcome measurement, disability and success of surgery are associated with patient-specific characteristics, type of pathology, symptom location, severity, and chronicity. Statistically, observations related to each patient in orthopaedic research should be independent and specific to a particular joint to produce accurate results and conclusions. Independence of observations eliminates using highly correlated measures of the same person (when two joints of the

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same patient are used twice for analysis)[1–3] and eliminates the impact of other joints' symptoms and dysfunction.

There is some information on bias related to using patients with bilateral problems as independent cases due to violating the assumption of independence.[1–4] However, we are not aware of data regarding the impact of bilateral symptoms on disability assessment. Investigating the matter would add to the body of the literature in this area, especially if different shoulder pathologies are not grouped together. When examining bilaterality as a potential source of bias, age, sex, and dominant side involvement should also be taken into consideration within the type of pathology.

The purposes of this study were to (1) examine the prevalence of bilateral shoulder complaints in patients with rotator cuff impingement syndrome (IS), rotator cuff tear (RCT), and osteoarthritis (OA) of the glenohumeral joint, (2) explore risk factors associated with symptom bilaterality (e.g. older age, female sex, type of pathology and dominant side involvement), and (3) examine the impact of bilaterality and hand dominance on pre- and post-operative patient-oriented disability outcomes.

Materials and methods

This study involved secondary data analysis of prospectively collected data of patients who had surgery for their shoulder and had returned for their 1-year follow-up. These patients had participated in previous studies and their pre- and post-operative data had been entered into a research database. The inclusion criteria for the present study were the diagnosis of rotator cuff IS, full-thickness tear, or OA of the glenohumeral joint which was managed by rotator cuff decompression, rotator cuff repair, and total shoulder replacement, respectively. All patients were $\geqslant$18 years of age and had failed conservative treatment and proper rehabilitation of at least 6 months. Patients with ambidextrous limbs were not included in the analysis.

Patients were allocated to the 'bilateral group' if they had reported significant symptoms such as pain, stiffness, or weakness in the opposite shoulder affecting their function at the time of pre-operative assessment. Due to secondary analysis of data, requirement to obtain written informed consent from subjects was waived by the Institutional Review Board. Approval for use of existing data for secondary analysis was obtained from the Research Ethics Board of the Sunnybrook Health Sciences Centre.

Patient-oriented outcome measures

Two outcome measures were completed prior to surgery and 1 year after surgery: The American Shoulder and Elbow Surgeons (ASES)[5] and the Constant–Murley Score (CMS).[6] The ASES is a self-report joint-specific questionnaire which measures pain severity and perceived difficulty performing daily activities. The CMS is a mixed subjective and objective measure; the self-report component (35% of the total score) and the objective component which includes pain-free range of motion in four directions and strength in the scapular plane (65% of the total score). For the purpose of this study, the relative CMS which adjusts for age- and sex-related changes was used. The ASES and CMS have been reported to be valid and reliable in patients with shoulder pathology.[5–9] These measures were completed 2–3 weeks prior to surgery and 1 year after surgery.

Surgical procedures

Patients with IS secondary to subacromial or acromioclavicular osteophytes and patients with partial thickness RCTs of $<$50% tendon thickness underwent arthroscopic rotator cuff decompression (IS group). Patients with full-thickness tears of the rotator cuff underwent arthroscopic repair of the tendon(s) (RCT group). Patients with advanced primary OA of glenohumeral joint underwent shoulder arthroplasty (OA group).

Statistical methods

The sample size for an independent t-test analysis was estimated based on the assumption of medium Cohen's effect size (0.05), power of 0.80, and α of 0.05. A minimum sample size of 64 was required for each subgroup (bilateral and unilateral) within each diagnostic group. The descriptive disability data were calculated for the ASES and relative CMS scores. The relationship between presence of bilateral symptoms and age, sex and dominant side involvement was examined within each pathology group with chi-square statistics. The paired t-test statistics examined the change in disability measures (ASES, relative CMS) over time. Independent t-test statistics were used to examine the potential differences in pre, post, and change of the ASES and relative CMS between the unilateral and bilateral groups and between dominant versus non-dominant hand groups. The Satterthwaite method was used to account for group size differences of normally distributed data. Statistical analyses were performed using SAS® version 9.1.3 (SAS Institute, Cary, NC). Statistical results are reported using two-tailed p values with significance set at $p < 0.05$.

Results

Data of 772 patients, mean age 60, 376 females, 396 males were included in the analysis. The IS, RCT, and OA groups included 288, 332, and 152 patients. Two hundred and twenty-two (29%) patients had significant bilateral shoulder problems and 510 (66%) patients had surgery on their dominant side. The prevalence of bilateral symptoms was 28%, 22%, and 44% in the IS, RCT, and OA groups, respectively ($X^2 = 24.25$, $p < 0.0001$).

The older age and female sex were associated with higher prevalence of bilateral symptoms in patients with RCT. Age,

Table 1. Patient characteristic differences between groups with bilateral and unilateral symptoms (N = 772).

Variables	Bilateral	Unilateral	Statistics p values
Type of pathology			
• IS (288)	81 (28%)	207 (72%)	$\chi^2 = 24.25$, $p < 0.0001$
• RCT (332)	74 (22%)	258 (78%)	
• OA (152)	67 (44%)	85 (56%)	
Sex (female/male)			
• IS	34/47 (42%)	104/103 (50%)	$\chi^2 = 1.59$, $p = 0.21$
• RCT	41/33 (55%)	110/148 (43%)	$\chi^2 = 3.78$, $p = 0.05$
• OA	37/30 (55%)	50/35 (59%)	$\chi^2 = 0.19$, $p = 0.66$
Age (mean, SD)			
• IS	55 (11)	53 (13)	t-test = 1.41, p = 0.16
• RCT	64 (10)	61 (10)	t-test = 2.28, p = 0.02
• OA	67 (9)	68 (8)	t-test = 0.60, p = 0.55
DSI (yes/no)			
• IS (193/95)	50/31 (62%)	143/64 (69%)	t-test = 1.42, p = 0.23
• RCT (237/95)	38/36 (51%)	198/60 (77%)	t-test = 18.53, $p < 0.0001$
• OA (80/72)	34/33 (51%)	46/39 (54%)	t-test = 0.17, p = 0.68

IS: impingement syndrome; RCT: rotator cuff tear; OA: osteoarthritis; DSI: dominant side involvement; SD: standard deviation.

sex or dominant side involvement were not significant risk factors in the development of bilateral symptoms in patients with IS or OA of the glenohumeral joint OA (Table 1).

The prevalence of dominant side involvement was 71%, 67% and 53% in the RCT, IS and OA groups ($X^2 = 22.35$, $p < 0.0001$) indicating an association between type of pathology and dominant hand involvement. Of interest, patients with dominant side RCT often had unilateral symptoms ($p = 0.02$).

There were no statistically significant differences ($p > 0.05$) in pre or post ASES or relative CMS scores between patients with bilateral and unilateral symptoms regardless of type of pathology (Table 2). No statistically significant group differences were observed in the amount of change made in either outcome over a period of 1 year.

Similarly, no differences were detected in ASES or relative CMS between patients who had a dominant side involvement versus those who had a non-dominant side involvement ($p > 0.05$). No group differences were observed in the amount of change made in either outcome over a period of 1 year (Table 3).

Table 2. Patient-oriented outcome differences between groups with bilateral and unilateral symptoms.

Variables	Bilateral	Unilateral	Statistics p values
ASES Scores[a]			
• IS			
○ Pre	47 (18)	47 (19)	t-test = 0.22, p = 0.82
○ Post	75 (23)	74 (24)	t-test = 0.51, p = 0.61
• RCT			
○ Pre	47 (23)	45 (20)	t-test = 0.58, p = 0.56
○ Post	73 (21)	77 (26)	t-test = 1.36, p = 0.18
• OA			
○ Pre	34 (16)	30 (17)	t-test = 1.41, p = 0.16
○ Post	81 (13)	80 (17)	t-test = 0.22, p = 0.82
CMS[a]			
• IS			
○ Pre	46 (19)	51 (19)	t-test = 1.92, p = 0.06
○ Post	83 (24)	83 (27)	t-test = 0.02, p = 0.98
• RCT			
○ Pre	47 (23)	49 (20)	t-test = 0.58, p = 0.56
○ Post	81 (24)	84 (26)	t-test = 0.73, p = 0.47
• OA			
○ Pre	28 (15)	28 (15)	t-test = 0.06, p = 0.95
○ Post	85 (19)	84 (23)	t-test = 0.08, p = 0.93

ASES: American Shoulder and Elbow Surgeons; IS: impingement syndrome; RCT: rotator cuff tear; OA: osteoarthritis; CMS: Constant–Murley Score.

[a]There were no statistically significant differences between groups in the amount of change made in ASES or CMS scores over a period of 1 year.

Discussion

The present study provides information on the prevalence of bilateral symptoms and risk factors associated with different major pathologies of the shoulder joint. A higher age and the female sex were significant risk factors for having bilateral symptoms only within the RCT group. Males with IS and OA appeared to have less bilateral symptoms which may be related to stronger muscle function and less compensatory use of the opposite shoulder. Reduced variability of age within the OA group may explain insignificant impact of this factor on development of bilateral symptoms. Due to lack of information on the prevalence and risk factors associated with symptom bilaterally, further assessment of our findings is warranted.

Table 3. Patient-oriented outcome differences between groups with dominant side versus non-dominant side involvement.

Variables	Dominant side	Non-dominant side	Statistics p values
ASES Scores[a]			
• IS			
○ Pre	47 (18)	46 (19)	t-test = 0.47, p = 0.62
○ Post	74 (24)	74 (25)	t-test = 0.51, p = 0.61
• RCT			
○ Pre	46 (20)	46 (22)	t-test = 0.11, p = 0.91
○ Post	77 (21)	74 (24)	t-test = 0.79, p = 0.43
• OA			
○ Pre	34 (17)	29 (16)	t-test = 1.41, p = 0.16
○ Post	81 (16)	80 (14)	t-test = 0.01, p = 0.99
CMS[a]			
• IS			
○ Pre	51 (19)	46 (21)	t-test = 1.99, p = 0.05
○ Post	84 (26)	81 (27)	t-test = 0.98, p = 0.32
• RCT			
○ Pre	49 (19)	47 (22)	t-test = 0.38, p = 0.70
○ Post	84 (25)	83 (26)	t-test = 0.24, p = 0.81
• OA			
○ Pre	28 (15)	28 (14)	t-test = 0.24, p = 0.81
○ Post	83 (22)	86 (21)	t-test = 0.64, p = 0.52

ASES: American Shoulder and Elbow Surgeons; IS: impingement syndrome; RCT: rotator cuff tear; OA: osteoarthritis; CMS: Constant–Murley Score.
[a]There were no statistically significant differences between groups in the amount of change made in ASES or CMS scores over a period of 1 year.

The higher frequency of dominant side involvement in patients with rotator cuff pathology (71% in RCT vs 53% in OA) has been acknowledged in the literature[10,11] and may be attributed to the nature of cuff disease often related to overuse and trauma involving the dominant side. Similar to our study, in a study by Keener et al.,[11] a strong association was noticed between pain and dominant side involvement with 62% of patients with asymptomatic RC tear in the contralateral side and 70% of patients with unilateral RC tear reporting dominant side involvement. The authors highlighted that hand dominance posed a risk factor for RC tear development. In another study by Yamamoto et al.,[10] who examined over 600 elderly residents, hand dominance was a significant independent risk factor for development of RC tear.

In the present study, we found that patients with bilateral shoulder or dominant side involvement did not report higher levels of disability based on the ASES or relative CMS. Therefore, the potential bias that appears to be associated with using patients with bilateral symptoms was insignificant in our study. It is reasonable to assume that since relative CMS is a mixed objective/subjective measure, it would be more specific to the affected shoulder. Similarly, despite the subjective nature of the ASES, this measure also demonstrated the same insignificant differences between bilateral/unilateral and dominant/non-dominate side involvement across pre, post, and change over time.

We could not find studies that have specifically investigated the impact of bilateral symptoms on the level of disability. Most of the literature related to bilaterality of shoulder problems has investigated a different matter; a bias introduced secondary to high correlation of data of patients with two joint involvement.[2,3] There is more information on hand dominance and its impact on subjective measures. It is reported that individuals after distal radius fracture have shown increased difficulty with certain tasks reflected on the disabilities of the arm, shoulder and hand (DASH) score when the dominant side is affected.[12] In a study of 65 patients, Ozaras et al.[13] found that the DASH and pain with activity correlated positively in patients with dominate side involvement and not in those with non-dominate side involvement. The authors, however, did not compare the two groups in terms of disability. Edelmann et al.[14] found no differences in DASH scores in patients after proximal humerus fracture when the dominant limb was involved. In a study by Kachooei et al.,[15] dominant hand involvement, trauma, shoulder involvement, and female sex were associated with significantly higher DASH scores, but accounted for only 10% of the variability in scores which may not be clinically significant. The authors highlighted the role of psychological factors in perceived disability. We agree with Kachooei et al.[15] and other authors[16–19] who have investigated the role of psychological factors on patient-reported disability measures. We feel that better coping ability and adaptation to musculoskeletal disability would overpower the pain and functional disturbances arising from involvement of the dominant arm. In summary, using patients with significant symptoms and functional difficulty in the opposite shoulder will not bias the results of observational studies if outcomes are based on routine disability measures such as ASES or CMS.

Limitations

Generalizability of the present study may be limited as the patients were operated on by a single surgeon specialized in shoulder reconstruction in an academic centre. Considering disability was measured by two joint-specific outcome measures, our results are applicable to these two particular measures. Due to retrospective nature of the study, certain important factors such life style factors (e.g. smoking) and radiological findings (glenoid inclination or lateral acromial offset) were not taken into consideration. In the present study, the symptom bilaterality was based on patient's subjective report of significant symptoms and dysfunction of any origin and was not based on a specific pathology confirmed on imaging. Further assessment of the origin of the symptoms of the opposite shoulder will add to our understanding of the impact of bilaterality on perceived disability.

Conclusion

This study shows that patients with OA of the glenohumeral joint have the highest prevalence of bilateral shoulder

complaints. The older age and the female sex increased the risk of having bilateral symptoms in patients with RCT. Having bilateral shoulder symptoms or dominant side involvement was not associated with higher level of disability prior to or after surgery when measured with ASES and CMS.

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Declaration of conflicting interests

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Ethical approval

This study received ethics approval from the Human Ethics Research Board of the Sunnybrook Health Sciences Centre, Toronto, Canada: REB# 232-2012.

Informed consent

The requirement to obtain written consent was waived by the Independent Ethics Committee (IRB) because this study involved a secondary analysis of available data.

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