Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Journal of Orthopaedics 25 (2021) 151–154

Contents lists available at ScienceDirect

Journal of Orthopaedics

journal homepage: www.elsevier.com/locate/jor

Epidemiologic impact of COVID-19 on a multi-subspecialty orthopaedic practice☆

Braiden M. Heaps, Karen Ladnier, William T. Haselman *, Orr Limpisvasti, Michael B. Banffy

The Kerlan-Jobe Orthopaedic Clinic, Los Angeles, CA, USA

ARTICLE INFO

Keywords:
COVID-19
Pandemic
Epidemiology
Orthopedics
Surgery
Distal biceps rupture

ABSTRACT

The purpose of this study is to report the change in surgical case volume and composition encountered by a multi-subspecialty orthopaedic practice due to COVID-19. We reviewed electronic medical records for patients who had surgery at our institution and collected multiple variables including age and the joint that was operated on.

In the post-COVID-19 period, we found a significant increase in the percentage of hip procedures, and a significant decrease in the percentage of hand/wrist procedures. Overall, the total surgical volume of our multi-subspecialty orthopaedic practice decreased due to the COVID-19 pandemic, and the composition of surgical cases changed.

1. Introduction

SARS-CoV-2 (COVID-19) has had a dramatic and profound effect across the globe and particularly in the United States. As of October 12, 2020, there have been nearly 8 million cases in the US with over 215,000 deaths.[1] The pandemic has brought about widespread changes to routine daily life. These changes include large portions of the American work force now working from home, limited options for entertainment and recreation, cancellation or postponement of many levels of sports, and most impactful, stay at home orders.[2,3]

These changes have directly impacted the practice of orthopaedic surgery in the US. In March of 2020, due to rapidly increasing cases of COVID-19, the US Surgeon General recommended delay of elective and nonessential medical and surgical procedures. This recommendation was followed by similar recommendations by the Centers for Medicare & Medicaid Services (CMS), American College of Surgeons (ACS) and the American Academy of Orthopaedic Surgeons (AAOS).[4–6] The AAOS issued guidelines to help surgeons with management and triage of orthopaedic injuries from elective to emergent.[5] Given that a significant portion of orthopaedic surgical procedures are considered elective care, the impact of COVID-19 and these recommendations from governing bodies was immense.

Wong and Cheung studied Hong Kong's orthopaedic experience with COVID-19. They reported that during an early part of the pandemic (January 25 to March 27, 2020) orthopaedic procedures performed at all 43 public Hong Kong hospitals decreased by 44.2% with elective joint replacements and ligamentous reconstructions decreased 74%–84% compared to the 4 years prior.[7] Authors in Belgium,[8] Malaysia,[9] Argentina,[10] and Italy[11] reported their hospitals experience with caring for orthopaedic patients during the pandemic. Authors from the United States have also reported their experiences modifying their orthopaedic practices and caring for patients with orthopaedic injuries during the pandemic.[12–16]

Reports from the US to date detail the experience of orthopaedic trauma centers, but there is little published evidence about the experience of non-academic trauma center orthopaedic surgeons. The purpose of this study is to report the experience and pathology encountered at a high-volume multi-subspecialty orthopaedic practice before the COVID-19 pandemic and after the resumption of elective surgeries. To our knowledge this is the first report of its kind.

2. Methods

2.1. Study design and participants

We retrospectively reviewed the electronic medical records (EMR) of

☆ Dr. Banffy reports consulting and speaker fees from Stryker, consulting and speaker fees from Smith and Nephew, consulting and speaker fees from Vericel, outside the submitted work.

* Corresponding author. 6801 Park Terrace Dr. Suite 140 Los Angeles, CA, 90024, USA.
E-mail address: william.haselman@cshs.org (W.T. Haselman).

https://doi.org/10.1016/j.jor.2021.05.011
Received 1 March 2021; Accepted 2 May 2021
Available online 6 May 2021

all patients who had surgery at our institution from September 31, 2019 to September 4, 2020, inclusive. 2848 patients were identified. Data collected from the EMR included: Medical Record Number (MRN), age at the time of surgery, biological sex, joint that was operated on, diagnosis, date of surgery, the laterality of the procedure, and whether they were operated on in the pre-COVID-19 time frame or the post-COVID-19 time frame. The cutoff date for the pre-COVID-19 cohort was defined as the day before the governor of California announced a state-wide lockdown, which was announced on 3/19/2020. Thus, the pre-COVID-19 cohort (n = 1917) was defined as patients who underwent a surgical procedure occurring between 9/31/2019–3/18/2020, inclusive. The post-COVID-19 cohort (n = 913) was defined as surgeries occurring between 4/22/2020–9/4/2020, inclusive. The time period from 3/19/2020–4/21/2020, inclusive, was excluded because elective surgeries were banned during this time, thus we did not believe it was a fair representation of our private clinic's patient population. This study was approved by our institutions Institutional Review Board (IRB #00000934).

2.2. Statistical analysis

Data was analyzed by comparing the proportion of patients with an injury requiring surgery to a specific joint between the pre- and post-COVID-19 timeframes (Table 1). Significance was calculated by determining the standard error (SE) for the calculated proportions, then determining the SE for the difference between proportions and calculating a Z-score from that by dividing the absolute value of the difference between the pre- and post-COVID-19 proportions by the SE of the difference between the proportions. From that Z-score, we determined a p-value and significance was defined as a p-value < 0.05. The statistical analysis above was repeated for the specific diagnoses listed in Table 2. For both analyses, there were enough separate categories to assume independence.

3. Results

A total of 2830 (1917 pre-COVID-19 and 913 post-COVID-19) cases were analyzed within the time frame of the study. When broken down by the joint operated on (Table 1), we found a significant increase in the percentage of hip procedures performed ($+3.5 \pm 1.1\%$, $p = 0.002$), a significant decrease in the percentage of wrist procedures performed ($-2.6 \pm 0.8\%$, $p = 0.002$), and a significant decrease in the percentage of hand procedures performed ($-2.1 \pm 1.0\%$, $p = 0.027$) between the pre-COVID-19 and post-COVID-19 time frames. Foot, ankle, knee, shoulder, elbow, and back procedures showed no significant change in their respective percentage of total surgeries between the time frames.

When the cases were analyzed by diagnosis pre-COVID-19 vs. post-COVID-19 (Table 2), we found a significant increase in the percentage of adhesive capsulitis procedures ($+0.72 \pm 0.35\%$, $p = 0.0368$), arthritis/osteoarthritis procedures ($+3.32 \pm 1.40\%$, $p = 0.0174$), femoroacetabular impingement (FAI) procedures ($+1.50 \pm 0.76\%$, $p = 0.0473$), removal of loose bodies ($+1.26 \pm 0.55\%$, $p = 0.0218$), and distal biceps repair procedures ($+1.30 \pm 0.53\%$, $p = 0.0139$) performed in the post-COVID time frame. There was also a significant decrease in the percentage of trigger finger procedures ($-1.56 \pm 0.54\%$, $p = 0.0037$) in the post-COVID-19 time frame. Although not significant, there was also a trend towards an increase in the percentage of complete rotator cuff tear repairs ($+2.30 \pm 1.23\%$, $p = 0.0618$) and synovitis debridement procedures ($+1.18 \pm 0.62\%$, $p = 0.0589$) post-COVID-19. There were no other differences in the percentages of any other procedures performed on this population between these time periods.

4. Discussion

The coronavirus pandemic has changed the epidemiology of orthopaedic pathology requiring surgical intervention. While there is no single explanation for this alteration, several plausible explanations exist. One possible general reason for these changes is a decrease in out of the house work hours and an increase in free time available that would otherwise be occupied by out of the home work obligations due to the pandemic. Pathology specific reasons may also exist. A potential explanation for our observed increase in surgical treatment of FAI, might be due to patients attempting to capitalize on a newly found downtime. The downtime would be newly found time they had away from work or competitive sports participation. This downtime represented an opportunity window where patients could have the surgery they need and have an adequate period away from work or sport obligations to recover with minimal impact on their work life or athletic career. It is also possible many patients suddenly found themselves spending more of their time in a seated position leading to increase in the frequency, and potentially, the severity of their impingement symptoms. Another potential explanation that could account for a portion of the increase in surgically treated FAI is patients finding a new form of exercise. Many regions of the country had public exercise options limited due to closure of swimming pools and fitness centers. It is possible that patients who typically exercise in this setting decided to take up outdoor running as a safe alternative to maintain fitness. Running can potentially aggravate FAI symptoms and it has been reported that hip arthroscopy leads to a high return to running rate.[17–19] It is likely that all these factors contributed in some fashion to our observed increase in treatment for FAI. Our observed increase in removal of loose bodies again potentially could be explained by an increase in patients perceived time available to recover, as they were already not working, working from home, and/or not participating in competitive sports.

The significant increase in adhesive capsulitis procedures again does not have a clear and concise explanation. Research supports a clear link between pro-inflammatory states and metabolic disease (e.g. diabetes, obesity, hypertension) and adhesive capsulitis.[20] Recent research on

Table 1
Epidemiology of Surgical Cases by Joint pre- and post-COVID-19.

	Number of Cases		Proportion of Total Cases		Standard Error		Difference between Proportions	SE(D)[a]	2-Sided P-value
	Pre-COVID	*Post-COVID*	*Pre-COVID*	*Post-COVID*	*Pre-COVID*	*Post-COVID*			
Body Part									
Foot	99	55	0.052	0.060	0.005	0.008	0.009	0.009	0.360
Ankle	95	49	0.050	0.054	0.005	0.007	0.004	0.009	0.648
Knee	722	328	0.377	0.359	0.011	0.016	0.018	0.019	0.364
Hip*	122	90	0.064	0.099	0.006	0.010	0.035	0.011	0.002
Shoulder	490	242	0.256	0.265	0.010	0.015	0.009	0.018	0.598
Elbow	127	68	0.066	0.074	0.006	0.009	0.008	0.010	0.430
Wrist*	114	31	0.059	0.034	0.005	0.006	0.026	0.008	0.002
Hand*	146	50	0.076	0.055	0.006	0.008	0.021	0.010	0.027
Back	1	0	0.001	0	0.001	–	0.001	0.001	0.317

Note: An asterisk (*) indicates a p-value < 0.05.
[a] Standard error between the difference in proportions.

Table 2
Epidemiology of Surgical Cases by Diagnosis pre- and post-COVID-19.

Diagnosis	Number of Cases		Proportion of Total Cases		Standard Error		Difference between proportions	SE(D)[a]	P-value (2-sided)
	Pre-COVID	*Post-COVID*	*Pre-COVID*	*Post-COVID*	*Pre-COVID*	*Post-COVID*			
AC Joint Separation	4	2	0.0021	0.0022	0.0010	0.0015	0.0001	0.0019	0.9560
Achilles Tendinosis/tendinitis	1	1	0.0005	0.0011	0.0005	0.0011	0.0006	0.0012	0.6363
ACL Rupture	177	83	0.0924	0.0909	0.0066	0.0095	0.0015	0.0116	0.8990
Adhesive Capsulitis*	5	9	0.0026	0.0099	0.0012	0.0033	0.0072	0.0035	0.0368
Arthritis/Osteoarthritis*	226	138	0.1180	0.1512	0.0074	0.0119	0.0332	0.0140	0.0174
Arthrofibrosis	13	6	0.0068	0.0066	0.0019	0.0027	0.0002	0.0033	0.9479
Carpal Tunnel	29	10	0.0151	0.0110	0.0028	0.0034	0.0042	0.0044	0.3453
Chondromalacia	47	27	0.0245	0.0296	0.0035	0.0056	0.0050	0.0066	0.4467
Complete tear of rotator cuff	172	103	0.0898	0.1128	0.0065	0.0105	0.0230	0.0123	0.0618
Dislocation of Shoulder Joint	7	1	0.0037	0.0011	0.0014	0.0011	0.0026	0.0018	0.1461
FAI*	51	38	0.0266	0.0416	0.0037	0.0066	0.0150	0.0076	0.0473
Fracture	108	48	0.0564	0.0526	0.0053	0.0074	0.0038	0.0091	0.6759
Glenoid Labrum Tear	67	33	0.0350	0.0361	0.0042	0.0062	0.0012	0.0075	0.8749
Hallux Rigidus	14	7	0.0073	0.0077	0.0019	0.0029	0.0004	0.0035	0.9176
Impingement Syndrome	115	51	0.0600	0.0559	0.0054	0.0076	0.0042	0.0093	0.6559
Incomplete tear of rotator cuff	107	52	0.0558	0.0570	0.0052	0.0077	0.0011	0.0093	0.9050
Instability	55	33	0.0287	0.0361	0.0038	0.0062	0.0074	0.0073	0.3055
Lateral Epicondylitis	15	8	0.0078	0.0088	0.0020	0.0031	0.0009	0.0037	0.7999
Lateral Meniscus Tear	71	37	0.0371	0.0405	0.0043	0.0065	0.0035	0.0078	0.6575
Loose body*	20	21	0.0104	0.0230	0.0023	0.0050	0.0126	0.0055	0.0218
Medial Epicondylitis	10	2	0.0052	0.0022	0.0016	0.0015	0.0030	0.0023	0.1801
Medial Meniscus Tear	244	116	0.1273	0.1271	0.0076	0.0110	0.0003	0.0134	0.9824
Patellar instability	7	8	0.0037	0.0088	0.0014	0.0031	0.0051	0.0034	0.1305
Patellar tendinitis	1	2	0.0005	0.0022	0.0005	0.0015	0.0017	0.0016	0.3068
Removal of Retained Hardware	9	6	0.0047	0.0066	0.0016	0.0027	0.0019	0.0031	0.5450
Rupture of Achilles	22	9	0.0115	0.0099	0.0024	0.0033	0.0016	0.0041	0.6902
Rupture of Distal Biceps Tendon*	17	20	0.0089	0.0219	0.0021	0.0048	0.0130	0.0053	0.0139
Rupture of Quadriceps Tendon	6	2	0.0031	0.0022	0.0013	0.0015	0.0009	0.0020	0.6390
Sprain of ATFL	11	5	0.0057	0.0055	0.0017	0.0024	0.0003	0.0030	0.9295
Synovitis	32	26	0.0167	0.0285	0.0029	0.0055	0.0118	0.0062	0.0589
Tear of Acetabular Labrum	42	20	0.0219	0.0219	0.0033	0.0048	0.0000	0.0059	0.9980
Tear of LCL	5	4	0.0026	0.0044	0.0012	0.0022	0.0018	0.0025	0.4745
Tear of MCL	10	2	0.0052	0.0022	0.0016	0.0015	0.0030	0.0023	0.1801
Tear of PCL	6	3	0.0031	0.0033	0.0013	0.0019	0.0002	0.0023	0.9461
Tear of UCL	35	17	0.0183	0.0186	0.0031	0.0045	0.0004	0.0054	0.9481
Trigger Finger*	55	12	0.0287	0.0131	0.0038	0.0038	0.0156	0.0054	0.0037

Note: An asterisk (*) indicates a p-value < 0.05.
[a] Standard error between the difference in proportion.

COVID-19 has established that the cellular receptor for COVID-19 is angiotensin-converting enzyme 2 (ACE2). As a result, ACE2 expression can be altered in patients with COVID-19 leading to metabolic disease.[21] Additionally, there is recent literature that demonstrates lifestyle changes resulting from the COVID-19 pandemic have led to an increase in metabolic disease along with diabetes and obesity.[22] Logically then this new onset increase in metabolic disease and inflammation could be contributing to the increase in patients being diagnosed with and surgically treated for adhesive capsulitis. There is also the smaller possibility it could be linked to the increase in COVID-19 cases. A meta-analysis by Henry et al. examined 18 studies on the severity of COVID-19 and the blood serum markers that differed from uninfected individuals. They discovered that along with many elevated non-inflammatory markers, there were 8 inflammatory markers elevated in patients with COVID-19 (CRP, PCT, IL-2R, IL-6, IL-8, IL-10, serum ferritin, and erythrocyte sedimentation rate).[23] Lho et al. found that inflammatory serum markers are also elevated in patients with adhesive capsulitis,[24] specifically, interleukin-6 (IL-6). While there are many possible explanations for increased serum levels of IL-6, both COVID-19 and adhesive capsulitis lead to an increase. The increase in adhesive capsulitis cases we treated could potentially represent a link between the virus and adhesive capsulitis which could represent another manifestation of COVID-19 infection. Further research must be done before we can call this link anything more than speculative, however.

We speculate a potential explanation for the increase in surgically treated distal biceps repair could be that patients who suddenly found themselves home with more free time chose to spend that free time in pursuit of home improvement projects and/or a new or increased weightlifting program. For many of these patients, who were office or desk workers, this represented a dramatic change in their day-to-day usage of their upper extremities.

Regarding the decreased number of trigger finger surgeries performed we have 2 hypotheses. First, patients' day to day lives again significantly changed with the potential that this change in activity lead to a decrease in symptomatic triggering. Second, as trigger finger is considered a minor procedure, we speculate patients who otherwise may have opted for surgical intervention did a personal risk benefit analysis and determined the symptoms of trigger finger did not outweigh the risk of potential COVID-19 exposure and infection therefore they elected to live with the symptoms rather than present to an operative suite. These possible causes however are only hypotheses and the actual causes of these increase warrant further research on the mechanism of injury and why people chose to get surgery.

It is also worth noting that in a relatively similar time period, the total post-COVID-19 surgical cases were less than half of the total pre-COVID-19 surgical cases (913 vs. 1,916, respectively). This speaks to the major decrease in volume that our clinic saw during the coronavirus pandemic. While we saw a significant change in the percentage of specific surgical procedures between the two time periods, most of the specific procedures demonstrated an overall decrease in the total

number performed during that time, even if the percentage increased. The only exceptions to this that had a significant result were distal biceps repairs which saw 17 cases in the pre-COVID-19 period and 20 in the post-COVID-19 period, loose body removals which saw 20 and 21 cases in the pre-COVID-19 and post-COVID-19 periods, respectively, and adhesive capsulitis procedures which saw 5 and 9 cases in the pre-COVID-19 and post-COVID-19 periods, respectively.

This study could be improved with a larger sample size of patients. This study also only reported on the patients that came to our outpatient clinic in our region, thus our study might not be a representative sample of all orthopaedic procedures performed throughout the country in different settings, such as academic orthopaedic institutions or hospitals, within the time frame of the study. Also, due to the recent nature of the coronavirus pandemic, the post-COVID-19 time frame has a smaller sample size than the pre-COVID-19 time frame so this study would have benefitted from a longer study period for the post-COVID-19 time frame. We also must consider that, because the two groups were split within a single year, that some of the changes in the epidemiology pre-COVID-19 versus post-COVID-19 could be explained by normal seasonal changes in activity level and athletic participation. The pre-COVID-19 time period was in the fall and winter, when more indoor sports are played, and the post-COVID-19 time period was in the spring and summer, when sports and activities tend to occur outside.

5. Conclusion

The total surgical volume of our multi-subspecialty orthopaedic practice decreased as a result of the COVID-19 global pandemic, and the composition of surgical cases changed. There surely is a multitude of explanations for these changes, however we speculate a few major themes largely contributing. We suspect change in lifestyle, time away from competitive athletics and work obligations, time sensitivity of treatments and severity of symptoms were the main contributors. During the COVID-19 pandemic patients were forced to weigh the benefits of surgery against the usual surgical risks and the risk of any potential COVID-19 exposure/infection. However, further exploration and research should be performed before a declarative statement can be made attributing these factors as definitive.

Disclosures

No other authors have any disclosures.

References

1 Johns Hopkins Coronavirus Resource Center. COVID-19 Map.
2 Newsome G (Executive DS of C. California State Executive Order.
3 Angell S (California SPHO. California Public Health Order.
4 Center for Medicare & Medicaid Services. Non-Emergent, Elective Medical Services, and Treatment Recommendations.
5 American Academy of Orthopaedic Surgeons. AAOS Guidelines for Elective Surgery.
6 American College of Surgeons. COVID-19: Recommendations for Management of Elective Surgical Procedures.
7 Wong JSH, Cheung KMC. Impact of COVID-19 on orthopaedic and trauma service: an epidemiological study. *J Bone Jt Surg - Am*. 2020;102(14):E80. https://doi.org/10.2106/JBJS.20.00775.
8 Hernigou J, Morel X, Callewier A, Bath O, Hernigou P. Staying home during "COVID-19" decreased fractures, but trauma did not quarantine in one hundred and twelve adults and twenty eight children and the "tsunami of recommendations" could not lockdown twelve elective operations. *Int Orthop*. 2020;44(8):1473–1480. https://doi.org/10.1007/s00264-020-04619-5.
9 Teo SH, Abd Rahim MR, Nizlan NM. The impact of COVID-19 pandemic on orthopaedic specialty in Malaysia: a cross-sectional survey. *J Orthop Surg*. 2020;28(2). https://doi.org/10.1177/2309499020938877.
10 Slullitel PA, Lucero CM, Soruco ML, et al. Prolonged social lockdown during COVID-19 pandemic and hip fracture epidemiology. *Int Orthop*. 2020. https://doi.org/10.1007/s00264-020-04769-6. Published online.
11 Grassi A, Pizza N, Tedesco D, Zaffagnini S. The COVID-19 outbreak in Italy: perspectives from an orthopaedic hospital. *Int Orthop*. 2020;44(8):1543–1547. https://doi.org/10.1007/s00264-020-04617-7.
12 LeBrun DG, Konnaris MA, Ghahramani GC, et al. Hip fracture outcomes during the COVID-19 pandemic: early results from New York. *J Orthop Trauma*. 2020;34(8):403–410. https://doi.org/10.1097/BOT.0000000000001849.
13 Bram JT, Johnson MA, Magee LC, et al. Where have all the fractures gone? The epidemiology of pediatric fractures during the COVID-19 pandemic. *J Pediatr Orthop*. 2020;40(8):373–379. https://doi.org/10.1097/BPO.0000000000001600.
14 Egol KA, Konda SR, Bird ML, et al. Increased mortality and major complications in hip fracture care during the COVID-19 pandemic: a New York city perspective. *J Orthop Trauma*. 2020;34(8):395–402. https://doi.org/10.1097/BOT.0000000000001845.
15 Stoker S, McDaniel D, Crean T, et al. The effect of shelter-in-place orders and the COVID-19 pandemic on orthopaedic trauma at a community level II trauma center. *J Orthop Trauma*. 2020;34(9):e336–e342. https://doi.org/10.1097/BOT.0000000000001860.
16 Lubbe RJ, Miller J, Roehr CA, et al. Effect of statewide social distancing and stay-at-home directives on orthopaedic trauma at a southwestern level 1 trauma center during the COVID-19 pandemic. *J Orthop Trauma*. 2020;34(9):e343–e348. https://doi.org/10.1097/BOT.0000000000001890.
17 Chen AW, Craig MJ, Yuen LC, Ortiz-Declet V, Maldonado DR, Domb BG. Five-year outcomes and return to sport of runners undergoing hip arthroscopy for labral tears with or without femoroacetabular impingement. *Am J Sports Med*. 2019;47(6):1459–1466. https://doi.org/10.1177/0363546519836429.
18 Loudon JK, Reiman MP. Conservative management of femoroacetabular impingement (FAI) in the long distance runner. *Phys Ther Sport*. 2014;15(2):82–90. https://doi.org/10.1016/j.ptsp.2014.02.004.
19 Levy DM, Kuhns BD, Frank RM, et al. High rate of return to running for athletes after hip arthroscopy for the treatment of femoroacetabular impingement and capsular plication. *Am J Sports Med*. 2017;45(1):127–134. https://doi.org/10.1177/0363546516664883.
20 Kingston K, Curry EJ, Galvin JW, Li X. Shoulder adhesive capsulitis: epidemiology and predictors of surgery. *J Shoulder Elbow Surg*. 2018;27(8):1437–1443. https://doi.org/10.1016/j.jse.2018.04.004.
21 Bourgonje AR, Abdulle AE, Timens W, et al. Angiotensin-converting enzyme 2 (ACE2), SARS-CoV-2 and the pathophysiology of coronavirus disease 2019 (COVID-19). *J Pathol*. 2020;251(3):228–248. https://doi.org/10.1002/path.5471.
22 Martinez-Ferran M, de la Guía-Galipienso F, Sanchis-Gomar F, Pareja-Galeano H. Metabolic impacts of confinement during the COVID-19 pandemic due to modified diet and physical activity habits. *Nutrients*. 2020;12(6). https://doi.org/10.3390/nu12061549.
23 Henry BM, De Oliveira MHS, Benoit S, Plebani M, Lippi G. Hematologic, biochemical and immune biomarker abnormalities associated with severe illness and mortality in coronavirus disease 2019 (COVID-19): a meta-analysis. *Clin Chem Lab Med*. 2020;58(7):1021–1028. https://doi.org/10.1515/cclm-2020-0369.
24 Lho YM, Ha E, Cho CH, et al. Inflammatory cytokines are overexpressed in the subacromial bursa of frozen shoulder. *J Shoulder Elbow Surg*. 2013;22(5):666–672. https://doi.org/10.1016/j.jse.2012.06.014.