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GENERAL ORTHOPAEDICS

The safe resumption of elective orthopaedic services following the first wave of the COVID-19 pandemic

A REVIEW OF 2,316 CONSECUTIVE CASES AND IMPLICATIONS FOR RECOVERY FOLLOWING FURTHER WAVES

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Aims

There is little published on the outcomes after restarting elective orthopaedic procedures following cessation of surgery due to the COVID-19 pandemic. During the pandemic, the reported perioperative mortality in patients who acquired SARS-CoV-2 infection while undergoing elective orthopaedic surgery was 18% to 20%. The aim of this study is to report the surgical outcomes, complications, and risk of developing COVID-19 in 2,316 consecutive patients who underwent elective orthopaedic surgery in the latter part of 2020 and comparing it to the same, pre-pandemic, period in 2019.

Methods

A retrospective service evaluation of patients who underwent elective surgical procedures between 16 June 2020 and 12 December 2020 was undertaken. The number and type of cases, demographic details, American society of Anesthesiologists (ASA) grade, BMI, 30-day readmission rates, mortality, and complications at one- and six-week intervals were obtained and compared with patients who underwent surgery during the same six-month period in 2019.

Results

A total of 2,316 patients underwent surgery in 2020 compared to 2,552 in the same period in 2019. There were no statistical differences in sex distribution, BMI, or ASA grade. The 30-day readmission rate and six-week validated complication rates were significantly lower for the 2020 patients compared to those in 2019 ($p < 0.05$). No deaths were reported at 30 days in the 2020 group as opposed to three in the 2019 group ($p < 0.05$). In 2020 one patient developed COVID-19 symptoms five days following foot and ankle surgery. This was possibly due to a family contact immediately following discharge from hospital, and the patient subsequently made a full recovery.

Conclusion

Elective surgery was safely resumed following the cessation of operating during the COVID-19 pandemic in 2020. Strict adherence to protocols resulted in 2,316 elective surgical procedures being performed with lower complications, readmissions, and mortality compared to 2019. Furthermore, only one patient developed COVID-19 with no evidence that this was a direct result of undergoing surgery.

Level of evidence: III

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Keywords: Elective orthopaedic surgery, Arthroplasty, SARS-CoV-2, Complications, De-skilling, Readmission, Mortality

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Introduction

COVID-19 and its variants caused massive disruption to elective orthopaedic services around the world in 2020 because of the redeployment of staff and equipment, and the repurposing of elective units, to manage the rapid rise in patients who required intensive care unit (ICU) admission.

There was concern that, on resuming surgery, the morbidity and mortality would be greatly increased based on the report by Lei et al,[1] which found that 44% of their patients required ICU admission following surgery with an overall mortality rate of 20.5%. Similarly, the COVIDSurg Collaborative[2] reported that there was a 9% mortality rate in patients testing positive seven days before surgery and a 20.4% mortality rate in patients testing positive following surgery. However, reassuringly, the theoretical calculation by Kader et al[3] showed that the probability of acquiring SARS-CoV-2 infection in elective surgery with a false negative preoperative test would be 0.07% (around one in 1,400, using an estimated prevalence of 0.24% in May 2020). Applying the worst-case fatality (20.5%) to this, they calculated that approximately one in 7,000 patients undergoing an elective orthopaedic procedure would die of the disease.

The aim of this study was to determine whether the pathways and protocols that had been introduced were safe and effective, despite the concerns raised by earlier reports.[1,2]

Methods

A retrospective service evaluation of 2,316 consecutive patients admitted between 16 June 2020 and 12 December 2020 (26 weeks) was undertaken. Data were also obtained on 2,552 procedures performed during the same period in 2019. The most common regions operated on were the shoulder, hip, knee, foot, and ankle. Hand, spine, and other cases were not analyzed in detail. Patient demographic data, American society of Anesthesiologists (ASA) grade,[4] procedure types, 30-day readmissions, 30-day mortality, and six-week complications were compared with the same period in 2019, prior to the COVID-19 pandemic.

Local protocol for resumption of surgery. Elective surgery was resumed based on the Intercollegiate General Surgery guidance to "consider safety of all healthcare personnel, resource priorities, and infection rates in addition to the outcome of the individual patient"[5] and the British Orthopaedic Association (BOA) guidance for "restarting non-urgent trauma and orthopaedic care."[6]

The hospital was reconfigured to make the flow of patients in and out of the hospital unidirectional (a 'green-zone') with daily screening of all medical staff, wearing of face masks, social distancing, and frequent deep cleaning. Prior to restart, a very stringent preoperative assessment process was agreed upon, starting with the healthiest of our patients and those who needed less complex surgery. Within two weeks, major surgery was offered to lower-risk patients and after six weeks to a higher-risk group discussed at the anaesthetic multidisciplinary team (MDT) meeting.

Advice was provided to patients regarding self-isolation and shielding. Additionally, all patients required a negative COVID-19 polymerase chain reaction (PCR) test three days before surgery (Abbott M2000 (31.5 cycle threshold), Abbott House, UK and SAMBA II, Diagnostics for the Real World, UK). Patients were asked to use a face mask in hospital and relatives were not allowed in. Advice was given to self-isolate for two weeks following surgery. A summary of the pathway is shown in Figure 1.

Measurement of outcome. During the one-week postoperative telephone consultation (an additional welfare check following first lockdown) patients were specifically asked if they had developed COVID-19 symptoms. At a six-week follow-up paper questionnaire (collected only from those undergoing primary or revision shoulder, hip, or knee arthroplasty), patients were asked standard questions, such as whether they had a urine infection or deep vein thrombosis (DVT). Data were managed and obtained from the local outcomes database, Bluespier (Clanwilliam Group Digital Division, Ireland) and Lifebox (Definition Health Limited, UK) electronic computer databases and paper-based patient records. Data fields extracted were hospital number, date of birth, surgical procedure, date of procedure, ASA grade, type of anaesthetic, ethnicity, BMI, and outcome. Data regarding 30-day readmission were obtained for all patients who underwent surgery, from the Healthcare Evaluation Data (HED) system, which obtains data from Hospital Episode Statistics (HES), national inpatient and outpatient data, and Office of National Statistics (ONS) mortality datasets. Due to the three-month HES/HED lag time, 30-day readmission data were only available until 31 October 2020, and therefore 2019 data were analyzed to this timepoint for comparison. The data sources are summarized in Figure 2.

Ethics. As the data analyzed for this service evaluation were already routinely collected as part of direct clinical care, ethical committee approval for the evaluation was not required. No additional contact was made, or information collected from the patient, next of kin, general practitioner, or any other healthcare professional.

Statistical analysis. Data were tabulated using Microsoft Excel (Microsoft, USA) and analysis was undertaken using Microsoft Excel and Python version 3·9 using the openpyxl, pandas, and matplotlib libraries. independent-samples *t*-test, and Fisher's exact test were used. Odds ratio and relative risk were reported as indicated.

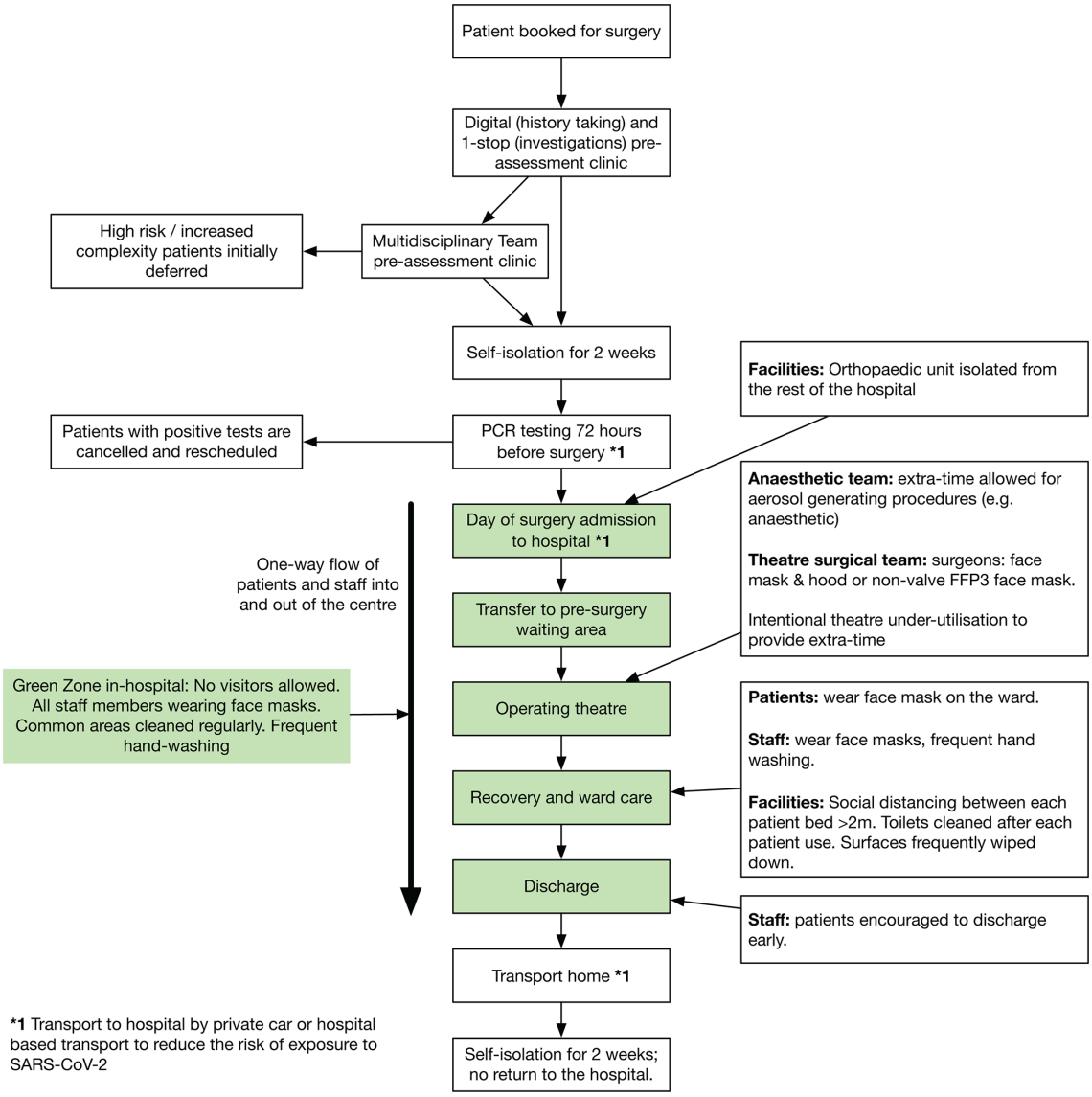

Fig. 1

Flowchart showing the COVID-19-safe patient pathway used in our hospital. PCR, polymerase chain reaction.

Results

During the 2020 study period, an equivalent of 794 all-day operating lists were performed (64 morning, 58 afternoon, and 733 all-day lists) compared to the same period in 2019 during which there was an equivalent of 778.5 all-day lists (79 morning, 74 afternoon, and 702 all-day lists). Although there were 15.5 fewer all-day lists during the 2019 period, more cases were operated upon (2,552 vs 2,316), with a mean of 3.28 (1 to 9) patients per list compared to 2.92 (1 to 9) in 2020. This was because there was a staged return to full operating lists to allow for any effects of deskilling and for increased turnover times due to the new protocols.

Procedure profiles, demographic data, and length of stay. The number of procedures performed is shown in Table I. A breakdown of the operations performed is shown for the knee (Table II), hip (Table III), shoulder (Table IV), and foot and ankle (Table V). The number of procedures performed, age, BMI, and ASA grades are shown for each month from June until December 2020, and the same period in 2019. In 2019, there were 875 primary total knee arthroplasties (TKAs) (2020: 665) and 723 total hip arthroplasties (THAs) (2020: 625), ten revision TKAs (2020: 32), and 68 revision THAs (2020: 24). There were more revision TKA procedures done in 2020 than 2019. The number of shoulder and elbow arthroplasties performed was 23 in both years. Following re-start, more general anaesthetics (38.4% vs 31.7%) and fewer spinal anaesthetics (53.7% vs 60.7%) were administered ($p < 0.001$, Fisher's exact test). The length of stay for all procedures was 0.5 days less in 2020 compared to 2019 (primary knee arthroplasties: one day less, primary

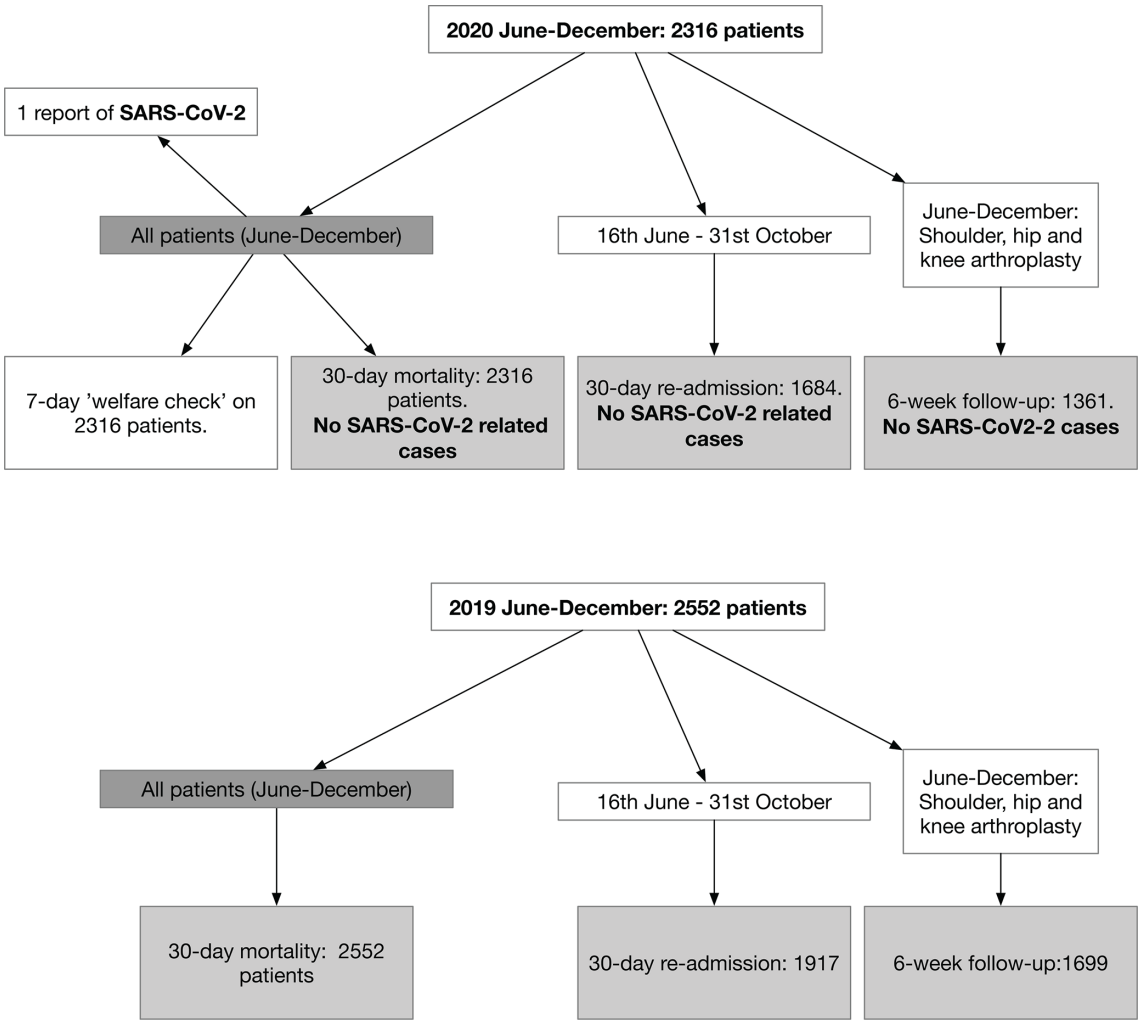

Fig. 2

Flow diagram showing the data sources (and patient numbers) for 2019 and 2020 patient groups.

Table I. The number of cases performed in 2019 and 2020 classified by body region.

Region	2019	2020
Knee	1,183	1,012
Hip	907	752
Foot and ankle	216	227
Shoulder and elbow	177	200
Hand	0	62
Spine	52	55
Other	17	8
Total	2,552	2,316

hip arthroplasties: 0.2 days less), but not statistically significant (data not shown).

The mean patient age in 2020 was 61.6 years (16.1 to 97.4 (SD 16.7)) compared to 64.4 years in 2019 (16.0 to 98.8 (SD 16.1); $p < 0.001$). There was no significant difference in sex distribution with 55.6% of patients being female in 2020 and 57% in 2019. The average BMI in 2020 was 29.3 kg/m^2 (16.9 to 53.5 (SD 5.8)) compared to 29.4 in 2019 (17.0 to 48.0 (SD 5.6); $p > 0.05$, $p = 0.710$, independent-samples t-test, two-tailed), but ASA grades were the same in 2020: 2.0 (1 to 4 (SD 0.7)) and 2019: 2.0 (1 to 4 (SD 0.6)).

30-day readmissions. Due to the three-month lag, HED/HES data were available for 1,684 cases in 2020, which were therefore compared with 1,917 cases performed in the same time period in 2019. Table VI shows the 30-day readmissions for 2020 (1,684 cases) and 2019 (1,917 cases) with the ICD-10 diagnostic codes in Table VII. These consisted of a mixture of medical and non-medical problems. 127 patients (6.62%) were readmitted within 30 days in 2019 compared to 50 patients (2.97%) in 2020. To keep our unit a 'Green' centre, all patients were re-admitted to other hospitals. The patients re-admitted in 2020 were younger (67.08 vs 70.30; $p = 0.135$, Fisher's exact test, two-tailed), but there was no difference in sex, ethnicity, or the number of days between surgery and the date of readmission.

Table II. Types of knee procedures undertaken between June and December in 2019 and 2020, before and after the first COVID-19 lockdown.

	Jun		July		Aug		Sept		Oct		Nov		Dec	
Procedure type	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Knee arthroscopy														
N	17	10	22	18	17	31	24	25	14	33	19	20	8	19
Mean age, yrs (SD)	45.38	41.52	44.18	40.55	49.24	40.55	43.44	51.43	47.7	52.18	51.12	42.73	40.89	40.49
SD	13.97	12.59	15.65	14.44	17.3	13.90	16.73	13.96	20.42	14.54	14.6	14.15	14.02	12.92
Range	22.95 to 69	23.22 to 63.34	20.62 to 64.46	18.20 to 70.39	21.76 to 79.02	21.84 to 73.83	16.8 to 76.56	28.07 to 82.39	16.92 to 92.25	22.66 to 73.42	26.6 to 74.86	18.71 to 62.48	18.08 to 59.7	23.41 to 71.05
Mean BMI, kg/m²	30.06	N/A	28.8	25.00	30.43	27.98	31	30.87	26	29.98	28	27.68	N/A	28.33
SD	5.34	N/A	6.97	3.41	5.68	3.71	4.9	3.55	N/A	5.64	7.21	3.89	N/A	4.61
Range	22 to 39	0	19 to 43	21.41 to 29.47	22 to 37	21.65 to 33.87	25 to 37	24.37 to 37.34	26 to 26	21.63 to 40.94	20 to 34	20.08 to 34.72	N/A	21.59 to 34.33
ASA grade, n														
1	9	6	12	13	5	16	15	8	9	16	8	12	5	10
2	5	4	9	5	10	13	8	12	2	16	8	8	2	7
3	3	0	1	0	1	2	1	4	3	1	3	0	1	2
4	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Primary knee arthroplasty														
N	61 (8 uni, 2 PFJ)	5 (2 uni)	151 (3 PFJs, 9 uni)	76 (3 PFJs, 9 uni)	124 (1 PFJ, 12 uni)	117 (1 PFJ, 8 uni)	145 (1 PFJ, 11 uni)	144 (3 PFJs, 18 uni)	182 (5 PFJs, 16 uni)	154 (1 PFJ, 19 uni)	147 (3 PFJs, 15 uni)	122 (19 uni)	65 (2 PFJs, 9 uni)	47 (3 uni)
Mean age, yrs	68.11	62.95	71.38	66.60	72.14	66.60	72.14	70.20	70.51	70.96	69.92	70.84	68.7	70.13
SD	9.89	6.30	9.2	9.66	9.15	10.04	8.87	8.65	9.43	8.98	8.66	8.85	9.48	10.80
Range	42.67 to 85.23	56.36 to 73.13	42.14 to 93.95	41.06 to 84.16	44.21 to 88.57	46.17 to 88.81	47.15 to 92.5	41.53 to 89.11	40.36 to 89.45	45.58 to 94.23	50.17 to 92.24	52.12 to 91.07	50.49 to 86.04	44.51 to 96.23
Mean BMI, kg/m²	31.33	N/A	30	29.18	30.31	30.44	32.56	30.18	30.26	31.00	30.33	31.44	30.67	33.11
SD	6.37	N/A	5.48	4.59	5.3	5.18	5.98	6.09	4.74	5.34	3.76	6.80	6.47	6.58
Range	18 to 47	0	18 to 48	21.27 to 39.82	19 to 45	21.30 to 41.22	20 to 47	17.49 to 47.38	21 to 42	19.76 to 43.82	24 to 38	18.99 to 53.52	22 to 47	21.94 to 47.67
ASA grade, n														
1	3	3	4	8	3	7	3	7	15	4	10	4	2	3
2	43	2	115	58	96	77	114	96	133	98	97	79	49	31
3	15	0	31	10	23	33	27	41	32	50	36	38	14	12
4	0	0	1	0	0	0	1	0	0	2	3	1	0	1
Revision knee arthroplasty														
N	0	0	1 (PFJ)	4 (1 PFJ)	2 (uni)	8 (1 PFJ, 1 uni)	1	5 (1 PFJ, 3 uni)	2 (2 uni)	6 (3 PFJs)	2 (uni)	4 (1 uni)	2 (1 PFJ, 1 uni)	5 (1 PFJ)
Mean age, yrs	N/A	N/A	51.46	68.27	73.23	68.27	68.87	75.28	71.86	72.19	71.04	75.31	63.66	75.14
SD	N/A	N/A	N/A	12.62	21.88	8.79	N/A	2.89	6.92	6.31	3.32	7.53	13.16	7.95
Range	N/A	N/A	N/A	56.24 to 81.86	57.76 to 88.7	58.47 to 80.98	N/A	73.15 to 80.01	66.97 to 76.75	62.24 to 79.71	68.69 to 73.39	64.51 to 81.98	54.36 to 72.97	65.06 to 82.48
Mean BMI, kg/m²	N/A	N/A	48	28.98	32	33.95	N/A	28.48	27	32.07	23	26.54	30	27.66
SD	N/A	N/A	N/A	4.99	N/A	6.66	N/A	2.16	5.65	8.93	N/A	N/A	N/A	3.26
Range	N/A	N/A	48 to 48	23.53 to 33.32	32 to 32	26.42 to 39.04	N/A	26.95 to 30	23 to 31	26.15 to 45.28	23 to 23	26.54 to 26.54	30 to 30	25.35 to 29.96
ASA grade, n														
1	N/A	N/A	0	1	0	0	0	0	1	0	0	0	0	1
2	N/A	N/A	0	3	2	3	1	4	1	3	1	3	1	2
3	N/A	N/A	1	0	0	5	0	1	0	3	1	1	1	2
4	N/A	N/A	0	0	0	0	0	0	0	0	0	0	0	0
Other knee procedures, n	23	14	26	25	19	23	31	32	24	27	38	19	16	19
Mean age, yrs	51.62	35.48	44.59	35.36	38.67	35.36	43.81	38.77	44.67	46.95	43.81	39.50	34.11	36.64
SD	22.61	13.78	18.29	14.24	17.11	19.04	20.01	19.60	20.38	19.42	21.79	14.30	15.38	18.62
Range	20.16 to 81.47	18.28 to 70.47	19.61 to 89.13	16.78 to 81.36	16.91 to 68.44	17.40 to 82.58	16.2 to 84.16	16.71 to 90.30	16.85 to 84.59	16.62 to 87.08	18.19 to 89.52	21.27 to 76.75	20.24 to 75.56	17.22 to 84.15
Mean BMI, kg/m²	28.45	25.26	27.59	24.78	29.5	26.55	32	28.17	25.75	30.06	26.5	29.29	25.5	26.15
SD	5.44	4.32	4.54	4.25	7.86	5.16	2.92	6.81	5.06	4.22	5.72	5.51	6.36	3.82
Range	19 to 41	22.2 to 28.31	20 to 35	19.72 to 29.96	20 to 44	18 to 35.63	30 to 37	22.43 to 48.52	20 to 32	23.55 to 37.51	20 to 36	23.23 to 40.68	21 to 30	20.78 to 33.4
ASA grade, n														
1	11	12	13	17	11	12	17	20	14	14	17	7	12	13

Continued

Table II. Continued

	Jun		July		Aug		Sept		Oct		Nov		Dec	
Procedure type	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
2	9	2	12	8	5	10	13	10	10	10	19	11	2	4
3	3	0	1	0	1	1	0	2	0	3	2	1	2	0
4	0	0	0	0	1	0	1	0	0	0	0	0	0	0

ASA, American Society of Anesthesiologists; N/A, not available; PFJ, patellofemoral joint replacement; SD, standard deviation; Uni, unicompartmental.

Table III. Types of hip procedures undertaken between June and December in 2019 and 2020, before and after the first COVID-19 lockdown.

	Jun		July		Aug		Sept		Oct		Nov		Dec	
Hip procedure	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Hip arthroscopy														
N	2	4	7	8	6	4	4	7	4	5	8	1	0	1
Mean age, yrs	42.97	35.82	36.97	36.07	36.97	36.07	32.52	33.10	25.95	32.38	32.4	16.33	N/A	30.11
SD	7.07	16.27	11.44	10.19	24.19	20.52	7.84	12.34	5.53	15.37	12.34	N/A	N/A	N/A
Range	37.97 to 47.96	20.65 to 58.09	23.11 to 50.95	20.85 to 48.54	16.78 to 85	18.94 to 66.97	22.65 to 40.25	19.48 to 58.76	20.27 to 30.9	22.06 to 59.26	16.08 to 53.6	16.33 to 16.33	N/A	30.11 to 30.11
Mean BMI, kg/m²	26	N/A	27	29.36	26.5	22.15	N/A	31.93	N/A	25.45	21	20.87	N/A	28.40
SD	8.49	N/A	4.9	9.59	4.2	4.65	N/A	6.89	N/A	2.48	4.24	N/A	N/A	N/A
Range	20 to 32	N/A	22 to 36	21.98 to 42.31	22 to 32	18.86 to 25.44	N/A	27.06 to 36.8	N/A	23.21 to 28.4	18 to 24	20.87 to 20.87	N/A	28.4 to 28.4
ASA grade, n														
1	1	4	2	5	3	2	3	5	2	4	7	1	N/A	0
2	0	0	5	3	3	2	1	1	2	1	1	0	N/A	1
3	1	0	0	0	0	0	0	1	0	0	0	0	N/A	0
4	0	0	0	0	0	0	0	0	0	0	0	0	N/A	0
Primary hip arthroplasty														
N	54	2	137 (2 hip resurfacing)	99 (2 hip resurfacing)	108	127	120 (1 hip resurfacing)	121 (1 hip resurfacing)	134 (2 hip surfacing)	112 (2 hip resurfacing)	116	108	60	56
Mean age, yrs	65.38	48.31	69.05	63.75	69.05	63.75	67.7	67.88	70.71	68.22	68.93	69.20	71.11	66.72
SD	15.36	10.07	11.09	11.88	11.25	10.79	12.86	12.09	11.3	12.01	12.09	12.21	10.49	10.24
Range	20.28 to 93.44	41.19 to 55.42	40.25 to 91.64	24.73 to 86.26	24.96 to 98.76	40.10 to 94.96	29.52 to 92.5	28.87 to 89.11	38.98 to 91.35	28.14 to 89.90	18.36 to 94.18	29.99 to 89.98	45.8 to 90.54	36.88 to 86.48
Mean BMI kg/m²	29.37	N/A	28.78	26.99	27.7	28.84	29.79	29.57	27.2	28.59	27.86	28.93	27.53	28.69
SD	5.31	N/A	5.51	5.76	5.42	5.67	5.75	6.48	4.98	5.96	4.82	6.09	6.32	4.76
Range	20 to 44	0	19 to 45	19.37 to 46.55	20 to 41	16.9 to 42.76	18 to 42	21.15 to 52.76	19 to 42	17.82 to 46.4	18 to 35	19.76 to 49.53	17 to 39	20.58 to 39.64
ASA grade, n														
1	6	1	17	18	13	8	16	9	12	12	6	4	6	8
2	36	1	103	72	78	94	89	86	94	65	88	77	41	34
3	11	0	15	9	16	25	15	26	24	34	19	27	11	14
4	1	0	1	0	0	0	0	0	1	1	2	0	1	0
Revision hip arthroplasty														
N	4	0	12	1	18	4	12	6	12	6	8	3	2	4
Mean age, yrs	69.39	N/A	65.83	54.20	65.83	54.20	73.12	63.42	66.13	68.54	76.24	88.90	67.06	72.36
SD	4.18	N/A	10.05	N/A	15.2	3.65	6.9	6.74	12.78	13.77	12.05	7.93	5.06	13.10
Range	64.43 to 73.72	N/A	43.58 to 79.59	54.20 to 54.20	26.87 to 88.39	69.50 to 77.55	64.92 to 89.49	56.92 to 75.87	37.92 to 81.84	52.54 to 82.57	58.12 to 92.88	79.97 to 95.13	63.48 to 70.63	55.53 to 86.90
Mean BMI, kg/m²	32	N/A	28.88	N/A	28.33	26.88	30	31.98	26	24.89	28	N/A	N/A	33.6
SD	4.32	N/A	3.04	N/A	5.34	3.90	5.48	7.55	6	1.57	N/A	N/A	N/A	12.08
Range	28 to 38	N/A	25 to 34	0	22 to 36	24.12 to 29.64	23 to 37	26.64 to 37.32	23 to 35	23.32 to 26.45	28 to 28	0	N/A	22.64 to 46.55
ASA grade, n														
1	0	N/A	1	0	0	0	0	1	1	0	0	0	0	0
2	4	N/A	8	1	12	2	8	4	7	4	6	0	2	3
3	0	N/A	3	0	6	1	4	1	4	2	1	2	0	1
4	0	N/A	0	0	0	1	0	0	0	0	1	1	0	0
Other hip procedures														
N	6	0	13	7	13	15	15	16	16	19	13	10	3	6
Mean age, yrs	53.81	N/A	61.83	48.00	61.83	48.00	54.63	52.04	61.96	57.69	55.91	62.98	60.81	56.60

Continued

Table III. Continued

	Jun		July		Aug		Sept		Oct		Nov		Dec	
Hip procedure	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
SD	16.5	N/A	17.03	19.43	14.77	19.87	16.26	16.98	18.27	16.19	20.07	17.90	3.86	23.21
Range	30.59 to 76.35	N/A	26.28 to 86.12	25.67 to 76.14	35.16 to 86.2	16.09 to 82.89	24.8 to 81.71	28.10 to 79.40	21.7 to 80.03	24.66 to 76.79	23.45 to 80.45	36.48 to 84.95	56.53 to 64.04	25.88 to 84.05
Mean BMI, kg/m²	29.5	N/A	26.44	26.23	27.5	26.80	32	27.66	36	26.20	34.67	28.58	N/A	21.98
SD	6.75	N/A	7.02	2.84	2.12	5.28	N/A	5.19	N/A	3.98	9.87	4.21	N/A	3.90
Range	23 to 41	N/A	20 to 29	24.22 to 28.23	26 to 29	20.87 to 33.67	32 to 32	21.93 to 32.87	36 to 36	19.49 to 33.74	28 to 46	23.53	N/A	18.05
ASA grade, n														
1	2	N/A	4	3	5	3	8	9	5	4	7	4	1	3

Table IV. Types of shoulder and elbow procedures undertaken between June and December in 2019 and 2020, before and after the first COVID-19 lockdown.

	Jun		July		Aug		Sept		Oct		Nov		Dec	
Shoulder and elbow procedure	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**	**2019**	**2020**
Primary arthroplasty														
N	1 (1 elbow arthroplasty)	0	7	1	4	3	5 (1 elbow arthroplasty)	4	1	6 (1 elbow arthroplasty)	4	5 (1 elbow arthroplasty)	1	4
Mean age, yrs	57.4	0	72.5	56.27	72.5	56.27	73.96	79.13	70.11	72.28	74.77	70.28	66.97	76.05
SD	0	0	7.04	N/A	9.99	7.04	6.43	9.19	0	9.23	5.02	5.94	N/A	8.50
Range	0	0	60.11 to 81.85	56.27 to 56.27	59.38 to 80.44	61.19 to 73.77	63.52 to 80.1	66.30 to 88.04	0	60.75 to 85.01	70.18 to 80.75	63.00 to 76.28	N/A	63.78 to 82.18
Mean BMI, kg/m²	20	0	27.86	30.78	32	N/A	29.5	24.1	N/A	N/A	24	N/A	N/A	N/A
SD	0	0	5.52	N/A	8	N/A	3.54	N/A	N/A	N/A	1.41	N/A	N/A	N/A
Range	0	0	23 to 39	30.78 to 30.78	24 to 40	N/A	27 to 32	24.1 to 24.1	N/A	N/A	23 to 25	N/A	N/A	N/A
ASA grade, n														
1	0	0	0	1	0	0	1	0	0	0	0	0	0	0
2	1	0	7	0	4	1	2	1	1	6	2	2	1	3
3	0	0	0	0	0	2	2	3	0	0	1	3	0	1
4	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Shoulder and elbow arthroscopy														
N	7 1 elbow arthroscopy)	10 (1 elbow arthroscopy)	15	26	18	12	22 (1 elbow arthroscopy)	22 (2 elbow arthroscopy)	27 (3 elbow arthroscopy)	21 (2 elbow arthroscopy)	19	25 (2 elbow arthroscopy)	11 (1 elbow arthroscopy)	7
Mean age, yrs	55.88	47.94	50.72	51.03	50.72	51.03	46.04	47.67	53.69	52.61	51.99	53.71	54.61	43.51
SD	13.61	12.83	15.23	14.88	13.81	19.80	13.49	15.76	14.03	12.04	14.11	14.57	12.25	16.16
Range	30.07 to 71.65	30.47 to 64.73	19.81 to 71.57	17.41 to 73.80	23.48 to 77.37	18.81 to 77.38	24.39 to 70.98	18.45 to 76.14	24.79 to 83.3	25.56 to 72.75	23.77 to 74.75	19.32 to 78.38	25.08 to 71.94	19.77 to 62.50
Mean BMI, kg/m²	27.8	N/A	29.82	33	30.5	30.70	28.67	23.71	33.5	26.99	29	25.36	N/A	N/A
SD	5.22	N/A	4.56	3.73	9.72	N/A	5.85	3.62	9.19	0.10	0	1.77	N/A	N/A
Range	22 to 36	N/A	24 to 40	29.55 to 36.73	20 to 47	30.7 to 30.7	20 to 35	19.84 to 27.85	27 to 40	26.92 to 27.06	29 to 29	24.1 to 26.61	N/A	N/A
ASA grade, n														
1	2	7	6	11	6	6	8	8	11	5	7	7	3	3
2	3	3	7	12	9	4	11	14	10	10	8	13	7	3
3	1	0	2	3	3	2	2	0	5	5	3	5	1	0
4	0	0	0	0	0	0	0	0	0	1	0	0	0	0
Other procedures														
N	4	3	4	7	6	4	7	10	6	11	3	8	4	9
Mean age, yrs	47.35	54.00	45.08	38.70	45.08	38.70	48.04	50.06	47.94	46.57	67.26	49.18	42.43	63.24
SD	11.01	9.76	17.82	13.49	16.28	9.69	15.38	10.31	18.04	15.19	13.83	20.38	22.86	17.99
Range	35.92 to 57.02	42.73 to 59.93	28.07 to 63.78	24.13 to 57.65	21.91 to 67.35	51.85 to 75.10	24.27 to 67.24	36.13 to 68.07	27.27 to 73.47	23.70 to 65.84	52.48 to 79.9	24.89 to 77.68	17.93 to 67.84	33.65 to 89.21
Mean BMI, kg/m²	31.5	N/A	27.5	20.14	27.5	29.92	28	N/A	28.5	22.7	25	N/A	N/A	N/A
SD	9.19	N/A	6.14	N/A	4.95	N/A	2.83	N/A	4.95	N/A	N/A	N/A	N/A	N/A

Continued

Table IV. Continued

Shoulder and elbow procedure	Jun		July		Aug		Sept		Oct		Nov		Dec	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
Range	25 to 38	N/A	23 to 36	20.14 to 20.14	24 to 31	29.92 to 29.92	26 to 30	N/A	25 to 32	22.7 to 22.7	25 to 25	0	N/A	N/A
ASA grade, n														
1	3	1	1	3	2	2	3	4	3	5	1	5	2	2
2	1	2	2	3	3	2	3	6	1	4	1	3	2	3
3	0	0	1	1	1	0	1	0	2	1	1	0	0	1
4	0	0	0	0	0	0	0	0	0	1	0	0	0	0

ASA, American Society of Anesthesiologists; SD, standard deviation.

Table V. Types of foot and ankle procedures undertaken between June and December in 2019 and 2020, before and after the first COVID-19 lockdown.

Foot & ankle	Jun		July		Aug		Sept		Oct		Nov		Dec	
	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020	2019	2020
N	14	16	34	39	54	37	20	37	34	45	36	41	24	12
Mean age, yrs	60.71	43.07	49.52	55.39	57.5	61.00	64.79	55.58	58.9	48.83	53.63	48.32	56.82	54.32
SD	21.13	13.26	21.04	17.46	16.73	14.15	13.32	16.09	18.77	16.89	18	17.11	12.47	11.72
Range	26.05 to 88.52	17.07 to 59.91	17.35 to 84.23	17.54 to 84.84	19.86 to 85.63	22.59 to 88.24	36.76 to 83.2	16.89 to 80.68	21.56 to 91.61	16.42 to 81.76	16.04 to 79.82	17.79 to 82.93	38.25 to 86.43	36.17 to 80.40
Mean BMI, kg/m²	26.5	N/A	27.96	28.88	27.41	28.46	29.8	29.70	25.9	30.21	31.67	30.59	29	28.24
SD	4.72	N/A	5.59	7.16	4.35	5.96	5.07	6.22	3.87	6.22	4.04	8.64	N/A	4.66
Range	20 to 38	N/A	18 to 37	0 to 35.11	21 to 35	19 to 40.77	23 to 36	21.15 to 50.7	19 to 31	20.12 to 45.45	28 to 36	19.61 to 50.87	29 to 29	21.12 to 33.77
ASA grade, n														
1	6	13	17	15	14	10	7	6	10	22	14	16	7	2
2	8	3	16	19	31	21	11	27	19	19	17	12	12	4
3	0	0	1	5	5	5	0	4	3	4	5	13	3	2
4	0	0	0	0	0	0	0	0	1	0	0	0	0	0

ASA, American Society of Anesthesiologists; SD, standard deviation.

Six-week complication data. Six-week complication data was collected for all upper limb, hip, and knee arthroplasty patients, consisting of 1,361 patients in 2020 and 1,699 patients in 2019. They either 'ticked' the various options shown in Table VIII or filled in the free text (Table IX).

In 2019, 278 patients (10.9%) reported a complication compared to 129 patients (5.6%) in 2020. The fact that there were significantly fewer complications in 2020 than 2019 ($p < 0.001$, independent-samples t-test, two-tailed), suggested that the protocols that were put in place were effective and that the return to surgery had been safe. DVT (free-text and not tick box) and pneumonia were significantly lower in 2020 compared to 2019 ($p < 0.05$).

Mortality rates. Data regarding 30-day mortality were available for all patients. There were no deaths reported in the 2020 group at 30 days as opposed to 14 deaths (0.5%) following surgery in the 2019 cohort, three of which (0.1%) occurred within 30 days.

Preoperative COVID-19-related cancellations. A total of 15 patients out of the 2,316 in the 2020 cohort (0.65%) were cancelled due to either having been in close contact with a PCR-confirmed case of COVID-19, having a positive PCR test, or having symptoms (Table X). Nine patients had a positive COVID-19 PCR test: four were re-tested negative prior to surgery, two were not contactable, one 'had a false positive test' and subsequently sought private treatment, and two had no further tests. Nine patients tested positive on preoperative testing, out of a total of 2,316 patient samples tested (99.611%).

If all nine positive reported COVID-19 tests were false, the specificity of the test would be 99.6%. It is unlikely that all tests were false positives because the virus was circulating in the community at the time of the study. This means that the specificity of the PCR test used in this study is over 99.6%.

COVID-19 infection after surgery. Only one patient in the 2020 cohort contracted COVID-19 infection following an ankle arthroscopy with debridement and microfracture. This was a 38-year-old patient with a history of asthma and bronchitis whose surgery had initially been postponed due to a flu-like illness (COVID-19 test negative). The patient was treated with antibiotics and surgery was rescheduled for five weeks later. A repeat test was negative four days beforehand and the arthroscopic procedure was uneventful, with the patient being discharged on the day of surgery. The patient then stayed overnight with a friend who was self-isolating but developed flu-like

Table VI. The 30-day readmission rate for all patients undergoing surgery during the 2019 and 2020 periods (16 June to 31 October). The 2020 patients were younger, but of similar sex, and re-admissions were at similar times following index procedure. Percentages quoted relate to the total number of complications in the given cohort.

Variable	2019 (n = 1,917)	2020 (n = 1,684)	p-value
30-day readmissions 16 June to 31 October (total), n	127	50	< 0.001*
Mean age, yrs	70.63	67.08	0.135†
SD	11.20	16.33	
Range	21 to 91	18 to 88	
Sex, n; M (%):F	55 (43):72	25 (50):25	0.503*
Mean days after primary procedure	11	12	0.884†
SD	7.97	6.92	
Range	0 to 30	1 to 30	
Primary procedure, n (%)			
Others (< 2)	12 (9)	11 (21)	0.044*
W401 – Primary total prosthetic arthroplasty of knee joint using cement	65 (51)	21 (41)	0.318*
W941 – Primary hybrid prosthetic arthroplasty of hip joint using cemented femoral component	29 (22)	15 (29)	0.338*
W381 – Primary total prosthetic arthroplasty of hip joint not using cement	8 (6)	4 (7)	0.742*
W581 – Primary resurfacing arthroplasty of joint	3 (2)	0	
W943 – Revision of hybrid prosthetic arthroplasty of hip joint using cemented femoral component	3 (2)	0	
W371 – Primary total prosthetic arthroplasty of hip joint using cement	2 (1)	0	
W403 – Revision of total prosthetic arthroplasty of knee joint using cement	3 (2)	0	
W383 – Revision of total prosthetic arthroplasty of hip joint not using cement	2 (1)	0	
Ethnicity, n			
99 – Not known	64	16	0.030*
A – British	53	25	0.400*
C – Any other White background	3	2	0.620*
D – White and Black Caribbean	0	1	0.285*
H – Indian	0	1	0.285*
J – Pakistani	1	2	0.193*
L – Any other Asian background	1	1	0.486*
M – Caribbean	1	0	1.000*
N – African	1	1	0.486*
S – Any other ethnic group	3	0	0.560*
Z – Not stated	0	1	0.285*

*Fisher's exact test.
†Independent-samples *t*-test.
SD, standard deviation.

symptoms five days later. A test two days later confirmed COVID-19 infection and during a telephone consultation 12 days after the operation, the patient reported that the respiratory symptoms were improving. No members of the clinical team had tested positive for COVID-19 two weeks before or after the date of the patient's surgery suggesting that infection was from outside the hospital.

Discussion

This study, performed in a high-volume elective orthopaedic centre, is reporting on the greatest number of patients who underwent planned surgery in the UK (during the pandemic) to date. From a total of 2,316 patients only one (0.04%) developed COVID-19 postoperatively. In contrast, a nationwide study reported an almost 60% pre-hospital or hospital-acquired COVID-19 infection rate following admission for a fractured neck of femur.[8] In this series, COVID-19 infection diagnosed within 30 days of admission was associated with a three-fold increase in mortality. These patients were from a different demographic to those in our current series and had undergone emergency surgery during the earlier part of the pandemic, when protocols and processes were less well developed.

The 30-day mortality rate and the total number of complications was less in 2020 than in the previous year. Additionally, chest infection and DVT were reduced in the 2020 group. While the procedure profiles had some differences, the 2020 patient group were on average three years younger, despite being otherwise matched for BMI, ASA grade, and sex. The 2020 patients underwent a more rigorous preoperative work-up and there were fewer patients on each operating list at the start, leading to reduced time pressure during operating. Better access to inpatient physiotherapy and possibly reduced length of stay may explain our observations. On the other hand, patient anxiety or fear of catching COVID-19 by attending hospital to seek advice may have reduced presentations to hospitals following initial discharge.

The return to full surgical activity was not as slow as had been predicted.[9] Surgery initially resumed with

Table VII. The ICD-10 diagnostic codes[7] for all patients who were re-admitted within 30 days of their primary procedure during the 2019 and 2020 periods (16 June to 31 October).

Procedure type	ICD-10 codes	Description	2019 (total = 127)	2020 (total = 50)
Surgical	M798	Other specified soft-tissue disorders	31 (24%)	6 (12%)
	M796, M255	Pain in limb/joint	21 (16%)	7 (14%)
	T845, T814, M009	Infection and inflammatory reaction due to internal joint prosthesis or infection following procedure. Pyogenic arthritis	8 (6%)	5 (10%)
	I802	Phlebitis and thrombophlebitis of other deep vessels of lower limbs	9 (7%)	1 (2%)
	L031	Cellulitis of other parts of limb	5 (3%)	4 (8%)
	T810, M250	Haemorrhage and haematoma complicating a procedure, not elsewhere classified, haemarthrosis	4 (3%)	1 (2%)
	I828, I269	Embolism and thrombosis of other specified veins	2 (1%)	1 (2%)
	T858, T848, T840, I870	All other surgical	7 (5%)	2 (4%)
Medical	J181, R060, J22X	Lobar pneumonia, unspecified, dyspnoea	5 (3%)	2 (4%)
	A415 & A 419	Sepsis	1 (7%)	0
	I635	Cerebral infarction due to unspecified occlusion or stenosis of cerebral arteries	2 (1%)	0
	R33X, N390	Retention of urine, UTI	3 (2%)	2 (4%)
	I200, R073	Unstable angina/ chest pain	2 (1%)	2 (4%)
		All other medical	20 (15%)	4 (8%)
Unrelated		All other unrelated	7 (58%)	13 (26%)

ICD, International Classification of Diseases of the World Health Organization; UTI, urinary tract infection.

soft-tissue procedures in healthy patients who had urgent clinical need, and progressed rapidly to undertaking arthroplasty procedures, returning to near full activity, as compared to 2019, within six weeks of resumption.

Theatre lists, for the first two months (June/July 2020), were intentionally underused to allow time for safe airway management (due to the aerosol-generating procedure risk), and to allow for surgeon and team 're-learning' due to the deskilling which may have occurred during the three-month period of disuse.[10] Additionally, there were difficulties in re-filling lists if patients were cancelled at short notice due to not completing the two-week isolation period before surgery, or having a positive PCR test shortly before surgery. No additional operative training was given to surgeons or staff, but lectures were provided regarding COVID-19, transmission, the use of personal protective equipment (PPE), and social distancing. Extra precautions were put in place to protect patients and staff from COVID-19 infection. Initially, this included the option of surgeons operating in pairs, the standardized use of PPE, and protocols for anaesthetic induction and extubating. With these precautions in place, no increase in complications was observed during the study period. The authors do, however, appreciate that the extent of any de-skilling may not become apparent until much later.

There were no 30-day deaths in the 2020 cohort, which is different to the results from Lei et al[1] who found a 20% mortality rate in 34 patients who developed COVID-19-related pneumonia while undergoing elective (orthopaedic and nonorthopaedic procedures) surgery between January and February 2020. In their analysis, old age, comorbidities, operating time, and complexity of operation were related to poor outcome.[1] In our pathway, patients were advised to self-isolate following surgery, patients in the 2020 group were slightly younger, and the ASA grades were similar to patients in the 2019 group.

We believe that the low complications and readmissions were achieved by the strict adherence to pathways aimed at preventing COVID-19 infection before, during, and after surgery. Only 15 patients (0.65%) had their procedure cancelled showing that the screening protocol, preoperative assessment, and triage processes were effective.

The high specificity of our test, like the 99.92% reported by The Office for National Statistics, is due to a combination of factors including self-isolation of patients before surgery, well-trained staff taking and processing samples, and the use of a lower RT-PCR cycle threshold of 31.[11]

Only one patient in the current series developed COVID-19 infection, in line with the theoretical calculated rate of 1:1,400 at a time of relatively low community transmission. However, staff risk, and mitigating factors such as self-isolation, PCR testing, and preoperative COVID-19 symptom screening, were not considered in this earlier publication.[3] The risk in the current series of 1:2,316 was lower than that published by Myles et al,[12] who reported an incidence of 1:833 in a cohort of 4,965 patients following the return to surgery in Australia during the second wave.

Limitations of the study include the accuracy of the data, for example the use of the ASA classification, which can be subjective, as well as the self-reporting of complications by patients, although these

Table VIII. 'Tick-box' complications six weeks following surgery, collected from patients who underwent hip, knee, or upper limb primary or revision arthroplasty. Complications that had been entered into a database are listed below. Some patients reported more than one complication. Fisher's exact test confirms significantly fewer six-week complications in 2020 compared to 2019.

Total surgical procedures	2019	Complications, n/1,699 (%)	2020	Complications, n/1,361 (%)	p-value*
Patients reporting one or more complications, n	278		129		< 0.001
Deep vein thrombosis	15	5.40 (0.88)	5	1.80 (0.36)	0.112
Diarrhoea and vomiting	17	6.12 (1.00)	9	3.24 (0.66)	0.330
Dislocation	0	0	1	0.36 (0.04)	0.445
Heart attack	1	0.36 (0.06)	0	0	1.000
Joint infection	5	1.8 (0.30)	5	1.80 (0.37)	0.759
Nerve palsy	1	0.36 (0.06)	0	0	1.000
Other surgery to joint	5	1.8 (0.30)	2	0.72 (0.15)	0.472
Periprosthetic fracture	1	0.36 (0.04)	2	0.72 (0.15)	0.588
Pneumonia	10	3.60 (0.59)	0	0	0.003
Pulmonary embolism	1	0.36 (0.04)	2	0.72 (0.15)	0.588
Stroke	2	0.72 (0.12)	0	0	0.506
Urine infection	49	17.63 (2.30)	17	6.12 (1.25)	0.002
Wound infections	37	13.31 (2.18)	24	8.63 (1.86)	0.438
'Free-text' complications	167		85		< 0.001

*Fisher's exact test.

Table IX. "Free-text" patient-reported complications (i.e. complications entered into a free-text box) six weeks following surgery. There was no significant difference between the 2019 and 2020 periods.

Complication type	Category	2019	Complications, n (%)	2020	Complications, n (%)	p-value*
	Patients who underwent shoulder, hip, or knee arthroplasty, n	1,699		1,361		
	Patients reporting one or more complications, n	278		129		
	Grouped 'free-text' complications, n	167		85		0.001
Surgery-related	Pain, stiffness, redness, swelling, numbness, calf swelling (no DVT); of limited surgical significance.	68	40.72 (4.00)	36	42.35 (2.65)	0.044
	Wound healing problems	21	12.57 (1.23)	10	11.76 (0.73)	0.204
	Cellulitis	10	5.99 (0.59)	2	2.35 (0.15)	0.078
	Infection	8	4.79 (0.47)	5	5.88 (0.37)	0.783
	Bleeding	4	2.40 (0.24)	1	1.18 (0.07)	0.390
	Stiffness needing MUA	0	0	1	1.18 (0.07)	0.445
Medical	Chest infection	3	1.80 (1.77)	0	0	0.259
	DVT	3	1.80 (1.77)	0	0	0.259
	Cardiovascular (MI/arrhythmia)	1	0.60 (0.06)	1	1.18 (0.07)	1.000
	Urinary infection	2	1.20 (0.12)	3	3.53 (0.22)	0.661
	Nausea and vomiting	2	1.20 (0.12)	0	0	0.506
	Constipation	1	0.60 (0.06)	3	3.53 (0.22)	0.329
Others	Other (e.g. anaemia, analgesia sensitivity, mouth ulcers)	28	16.77 (1.65)	18	21.18 (1.32)	0.550
	Unrelated to surgery and unknown	10	5.99 (0.59)	3	3.53 (0.22)	0.163
	Falls or other trauma	5	2.99 (0.29)	2	2.35 (0.15)	0.472
	General malaise	1	0.60 (0.06)	0	0	1.000

*Fisher's exact test.
DVT, deep vein thrombosis; MI, myocardial infarction; MUA, manipulation under anaesthesia.

were subsequently validated by a telephone call and review of medical records (except for cases of urinary tract infection and diarrhoea and vomiting). The strengths of the study include a retrospective review of contemporaneously recorded data, the validation of patient-reported complications during a separate telephone consultation by a specially trained nurse, and the large number of patients.

Table X Summary of the 15 patients who were cancelled before surgery because they were either in close contact with another person who tested positive for COVID-19, tested positive themselves, or had symptoms suggestive of COVID-19 infection.

Cancellation reason	Procedure	Cancellation number of days before surgery
Close contact with another person who has a positive test for COVID-19		
	Ankle arthroscopy	7
	Revision total knee arthroplasty	1
	Total hip arthroplasty	6
	Total hip arthroplasty	1
	Total knee arthroplasty	2
Positive test for COVID-19		
	ACL reconstruction	3
	Excision of Morton's neuroma	7
	Hammer toe correction	1
	Total hip arthroplasty	7
	Total hip arthroplasty	2
	Total hip arthroplasty	2
	Total hip arthroplasty	0
	Unicompartmental knee arthroplasty	7
	Unknown	3
COVID-19 symptoms	Hip injection	4

ACL, anterior cruciate ligament.

The results of this study demonstrate that it was safe to restart elective orthopaedic surgery after the first lockdown, with no increased risk of surgical complications due to deskilling of the surgeon or scrub team, or of contracting COVID-19 in the perioperative period. This means that it should also be possible to safely restart elective work after the current wave, although there is no room for complacency and strict adherence to the pathways and protocols remains essential.

Take home message

- Elective surgery was safely resumed following the cessation of elective operations during the COVID-19 pandemic in 2020 by strict adherence to protocols.
- There is no evidence of increased risk of surgical complications due to de-skilling of the surgeon or scrub team, or of contracting COVID-19 in the perioperative period.

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