



# Differences in Resumption of Orthopedic Surgery According to Characteristics of Surgery during COVID-19 Pandemic: National Registry Data

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**Background:** Healthcare services have been restricted after the coronavirus disease 2019 (COVID-19) outbreak. With the pandemic still ongoing, the patterns of orthopedic surgery might have changed. The purpose of this study was to determine whether the reduced volumes of orthopedic surgery were recovered over time. Among the trauma and elective surgery, which accounted for most orthopedic surgical procedures, we also sought to elucidate whether the changes in the volumes of orthopedic surgery differed according to the type of surgery.

**Methods:** The volumes of orthopedic surgery were analyzed using the Health Insurance Review and Assessment Service of Korea databases. The surgical procedure codes were categorized depending on the characteristics of the procedures. The actual volumes of surgery were compared with the expected volumes to elucidate the effect of COVID-19 on surgical volumes. The expected volumes of surgery were estimated using Poisson regression models.

**Results:** The reducing effect of COVID-19 on the volumes of orthopedic surgery weakened as COVID-19 continued. Although the total volumes of orthopedic surgery decreased by 8.5%–10.1% in the first wave, those recovered to a 2.2%–2.8% decrease from the expected volumes during the second and third waves. Among the trauma and elective surgery, open reduction and internal fixation and cruciate ligament reconstruction decreased as COVID-19 continued, while total knee arthroplasty recovered. However, the volumes of hemiarthroplasty of the hip did not decrease through the year.

**Conclusions:** The number of orthopedic surgeries, which had decreased due to COVID-19, tended to recover over time, although the pandemic was still ongoing. However, the degree of resumption differed according to the characteristics of surgery. The findings of our study will be helpful to estimate the burden of orthopedic surgery in the era of persistent COVID-19.

**Keywords:** *Coronavirus, Orthopedic surgical volume, Surgical category, Degeneration related, Outside activity-related*

Coronavirus disease 2019 (COVID-19) has impacted the use of healthcare services globally.<sup>1)</sup> Hospitals have decreased elective services to prevent patients from contracting COVID-19 and to utilize scarce healthcare resources for managing COVID-19.<sup>1)</sup> The government recommended that people minimize outside activities and refrain from visiting hospitals.<sup>2)</sup> In addition, patients were reluctant to visit hospitals because of concerns regarding the spread of COVID-19.<sup>3)</sup> Elective surgeries were consequently reduced and postponed due to these changes.<sup>1,3-5)</sup> The proportion of

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emergency/elective surgery increased according to the priority of surgery.<sup>1,4)</sup> In particular, the volume of orthopedic surgery, which consisted of a high proportion of elective surgeries, significantly decreased.<sup>1)</sup>

The surgical patterns might have changed as the COVID-19 pandemic continued. The COVID-19 pandemic has also changed the prevalence of diseases.<sup>6-8)</sup> The incidence of upper respiratory infections has decreased because of the strengthening of social distancing and growing interest in personal hygiene.<sup>6)</sup> As the COVID-19 pandemic persisted, people experienced more psychological distress, such as anxiety and depression.<sup>7)</sup> In the orthopedic field, public interest in sports activity decreased, resulting in fewer sports-related injuries.<sup>8)</sup> In contrast, degenerative arthritis might not be directly affected by COVID-19. However, the reduction in physical activity due to the COVID-19 pandemic may have aggravated the symptoms of degenerative arthritis.<sup>9)</sup> As the COVID-19 pandemic has not ended, the canceled surgeries would inevitably have to be resumed amid the risk of contracting COVID-19.<sup>10)</sup> Therefore, the resumed orthopedic surgeries would be expected to show different surgical patterns from those before the COVID-19 outbreak. Researching the change in surgical patterns seems to be crucial for effectively using limited healthcare resources in the era of persistent COVID-19. In addition, the number of orthopedic surgeries tends to increase and decrease according to the type of surgery every year. Thus, it is necessary to reflect on the previous change patterns to accurately elucidate the effect of COVID-19 on reducing orthopedic surgery. However, a few studies have reported the changing patterns in the volumes of orthopedic surgery reflecting previous data.<sup>5,11-13)</sup>

The purpose of this study was to determine whether reduced volumes of orthopedic surgery recovered as the COVID-19 pandemic continued compared to the expected volumes of surgery in South Korea. Among the trauma and elective surgeries that accounted for most orthopedic surgeries, we also aimed to elucidate whether the changes in the volumes of orthopedic surgery differed according to the type of surgery in South Korea. We hypothesized that the volume of orthopedic surgery, which was reduced due to COVID-19, recovered over time, even though the COVID-19 pandemic continued. We also hypothesized that degeneration-related surgery would show more recovery patterns than outside activity-related surgery.

## METHODS

### Collection of Data

The volumes of orthopedic surgeries from 2017 to 2020 were obtained using the Health Insurance Review and Assessment Service (HIRA) of Korea databases. All people in South Korea should be registered in the National Health Insurance Program, and all medical institutes must submit medical expense claims data to HIRA for reimbursement of each procedure. Thus, the volumes of surgery were obtained from the HIRA of Korea databases based on the surgical procedure code. The surgical procedure codes were categorized into emergency surgery, infection surgery, trauma surgery, and elective surgery, depending on the characteristics of each procedure.<sup>5)</sup> Emergency surgery consisted of fasciotomy (N0922 and N0923) and reduction of the dislocated joint (N0751 – N0756 and N0761 – N0765). Infection surgery included operation of osteomyelitis or bone abscess (N0021- N0026), and excision of the joint, including synovectomy (N0700, N0701, N0703, N0704, N0706, N0708, N0709, N0710, and N0718). Trauma surgery consisted of open reduction and internal fixation (ORIF, N0601 – N0605, N0611 – N0612, N1601 – N1606, N1611 – N1616, N0591 – N0593), external fixation (EF, N0981 – N0986), and hemiarthroplasty of the hip (N0715 and N2710). Elective surgery included total hip arthroplasty (THA, N0711, and N2070), total knee arthroplasty (TKA, N2072, and N2077), cruciate ligament reconstruction (CLR, N0880, and N0881), and rotator cuff repair (RC, N0936 – N0938).

The number of confirmed cases of COVID-19 per month was obtained from the Korea Disease Control and Prevention Agency. Since the first confirmed case of COVID-19 appeared in South Korea at the end of January 2020, three waves of COVID-19 occurred in South Korea in 2020.<sup>14)</sup> The first, second, and third waves were from February to April, from August to September, and from November to January 2021, respectively (Table 1, Fig. 1). The three waves were grouped into two (first wave vs. second and third waves) to evaluate the impact on the number of surgeries in the early stage of the COVID-19 pandemic and the impact thereafter. This study was exempted from the approval and the written informed consent by the Institutional Review Board of Seoul National University Boramae Medical Center.

### Expected Volumes of Orthopedic Surgery

A Poisson regression model was used to predict the volume of orthopedic surgeries. The number of operations in 2020 was modeled with a 95% confidence interval based

**Table 1.** The Number of Confirmed Cases of COVID-19 Per Month in South Korea in 2020

Month	No. of confirmed cases
January	11
February	3,139
March	6,636
April	979
May	703
June	1,331
July	1,506
August	5,642
September	3,865
October	2,699
November	7,690
December	26,538

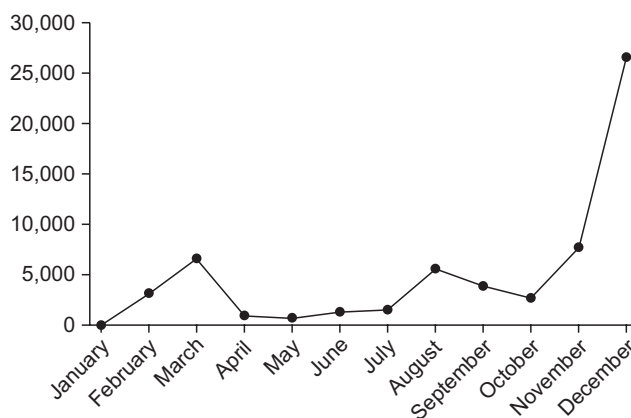
COVID-19: coronavirus disease 2019.

on data from 2017 to 2019. The total annual population of South Korea was set as an offset in the Poisson regression analysis. The expected volumes of surgery were calculated by multiplying the Exp (B) value obtained from the Poisson regression analysis and the number of surgeries in 2019. The actual volumes of surgery were compared with the expected volumes to elucidate the effect of the COVID-19 pandemic on surgical volumes. All data were analyzed using SPSS version 27 (SPSS Inc., Chicago, IL, USA).

$$\frac{(\text{Actual volumes of surgery} - \text{Expected volumes of surgery})}{\text{Expected volumes of surgery}} \times 100$$

## RESULTS

The effect of the COVID-19 pandemic on reducing the volume of orthopedic surgeries weakened as the COVID-19 pandemic continued. The total volume of orthopedic surgery decreased by 8.5%–10.1% (13,041.1–15,315.2 cases) in the first wave of COVID-19. However, the reduced surgical volumes recovered during the second and third waves of COVID-19, showing a 2.2%–2.8% decrease (5,566.7–7,038.3 cases) from the expected volumes (Table 2, Fig. 2). According to the categories of surgical procedures, elective, emergency, and trauma surgeries decreased in the first wave of COVID-19. During the second and third waves of COVID-19, elective surgery recovered with an absolute difference value of 2.8% compared to



**Fig. 1.** The number of confirmed cases of coronavirus disease 2019 (COVID-19) per month in South Korea in 2020.

that in the first wave, which was a 10.6%–11.6% decrease (9,725.5–10,659.4 cases) compared to the expected volumes. Emergency surgery even recovered to the expected volumes. In contrast, trauma surgery decreased, and infection surgery increased along with the wave of COVID-19 (Table 2, Fig. 2).

Outside activity-related surgery decreased as the COVID-19 pandemic continued, while degeneration-related surgeries recovered. However, the volume of fracture surgeries in the elderly did not decrease during the COVID-19 pandemic. The number of CLR surgeries decreased by 9.7%–13.8% (349.6–521 cases) in the first wave, which worsened to 18.5%–21.4% (1,151.9–1,378 cases) during the second and third waves of COVID-19. ORIF was also reduced as the COVID-19 pandemic continued. However, the EF and hemiarthroplasty surgeries were performed beyond expectations. EF surgery was performed more frequently during the second and third waves than during the first wave of COVID-19 (Table 3, Fig. 3). Conversely, TKA surgery decreased by 27.7%–29.0% (7,937.2–8,432.8 cases) in the first wave and recovered to 14.4%–15.5% (6,933.3–7,598.8 cases), lower than expected during the second and third waves of COVID-19. However, THA and RC repair, which did not decrease even in the first wave, decreased during the second and third waves of the COVID-19 pandemic (Table 3, Fig. 4).

## DISCUSSION

The COVID-19 pandemic, which has spread across the world, resulted in reduced volume of surgery.<sup>1,3-5)</sup> Orthopedic surgery cases have also been significantly decreased,<sup>1,4)</sup> and patients with degenerative arthritis complain that their pain worsened after their surgery was canceled.<sup>4)</sup> As

**Table 2.** The Volumes of Orthopedic Surgery Cases Depending on the Surgical Category during the Waves of COVID-19

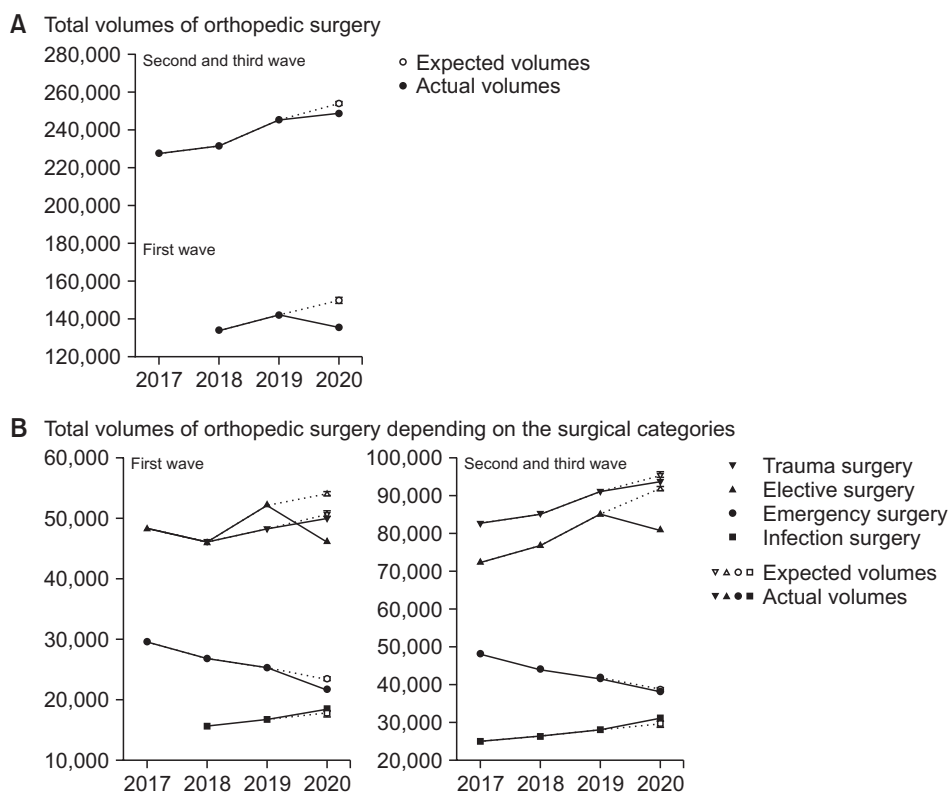
Variable	During the first wave (February–April, n)					During the second and third waves (August–December, n)					
	2017	2018	2019	2020		2017	2018	2019	2020		Difference (%) <sup>*</sup>
				Expected	Actual				Expected	Actual	
Total orthopedic surgery	-	134,470	142,130	149,947.2	135,769	227,652	231,265	245,272	253,856.5	247,554	-2.5
			(148810.1, 151084.2)					(253120.7, 254592.3)			(-2.8, -2.2)
Emergency surgery	29,505	26,803	25,383	23,453.9	21,440	47,873	43,900	41,528	38,538	38,411	-0.3
			(23250.8, 23657.0)					(38288.9, 38787.2)			(-1.0, 0.3)
Infection surgery	-	15,657	16,747	17,869.0	18,084	24,959	26,219	28,043	29,641.5	30,132	1.7
			(17483.9, 18271.0)					(29389.1, 29893.8)			(0.8, 2.5)
Trauma surgery	-	46,004	48,278	50,547.1	50,197	82,659	85,100	91,033	95,220.5	93,351	2.0
			(49919.5, 51223.0)					(94765.4, 95675.7)			(-2.4, -1.5)
Elective surgery	48,281	46,100	52,169	54,099.3	46,567	72,161	76,860	84,901	91,862.9	81,628	-11.1
			(53,786.2, 54,464.4)					(91353.5, 92287.4)			(-10.6, -11.6)

Values are presented as the number of each surgical procedure.

Ninety-five percent confidence intervals of the expected surgical numbers are expressed in parentheses.

COVID-19: coronavirus disease 2019. Diff: difference.

\*Difference between the expected and actual numbers of each surgical procedure.



**Fig. 2.** The volumes of orthopedic surgery cases during the waves of coronavirus disease 2019 (COVID-19). (A) Total volumes of orthopedic surgery cases. (B) The volumes of orthopedic surgery cases depending on the surgical category. Opened figure, expected volumes of surgery; Closed figure, actual volumes of surgery.

the pandemic has lasted longer than anticipated, many countries have been changing quarantine guidelines to accommodate COVID-19.<sup>15)</sup> In addition, orthopedic surgery could not be postponed indefinitely. Therefore, although there was a risk of contracting COVID-19, orthopedic surgery has been resuming. The principal finding of our study is that the reduced volumes of orthopedic surgery recovered even while COVID-19 persisted. However, the patterns of recovery differed depending on the characteristics of surgery.

The findings of our study confirmed our hypothesis that the volume of orthopedic surgery decreased with the first incidence of COVID-19, then recovered over time, even though the COVID-19 pandemic continued. Eighty-two percent of orthopedic surgeries were estimated to have been canceled during the peak 12 weeks of the COVID-19 pandemic.<sup>1)</sup> One study reported that orthopedic surgery had decreased by 44.2% during the first 9 weeks of the COVID-19 outbreak (from January 25th to March 27th) in Hong Kong, compared to the same period of the previous 4 years.<sup>5)</sup> However, as the COVID-19 pandemic lasted for more than several months, the postponed orthopedic surgery had to be resumed to alleviate pain, improve the quality of life, and prevent aggravation of the disease.<sup>16)</sup> Studies have reported recovery in the volume of orthopedic surgery, although the degree of recovery varied

depending on the country in which the study was conducted.<sup>17-19)</sup> Recovery patterns in the volume of orthopedic surgery were also found in our study in terms of elective and emergency surgeries. This discrepancy in the degree of recovery may have been due to two factors: the period included in the studies was different, and the number of COVID-19 confirmed cases in each country was also different.<sup>17-19)</sup> Our study included the entire period of 2020 when South Korea faced three waves of COVID-19. The number of COVID-19 confirmed cases in South Korea increased. However, as of December 2020, the ratio of the cumulative number of COVID-19 confirmed cases to the total population in South Korea was at the 161st place out of 218 countries worldwide.<sup>20)</sup> Therefore, the impact of the COVID-19 pandemic on reducing the volume of orthopedic surgeries may not be significant.<sup>20)</sup> In summary, the volumes of orthopedic surgery recovered as the number of COVID-19 confirmed cases decreased after the first wave. Although there was a difference in the degree of recovery according to country, recovery in the volume of orthopedic surgery was observed even after the COVID-19 outbreak again.

The findings of our study confirmed our hypothesis that the volume of degeneration-related surgery showed greater recovery than that of outside activity-related surgery. Trauma surgery was reported to have been reduced

**Table 3.** The Volumes of Orthopedic Surgery Cases Depending on the Surgical Procedure during the Waves of COVID-19

Variable	During the first wave (February–April, n)					During the second and third waves (August–December, n)					Diff, %*
	2017	2018	2019	2020		2017	2018	2019	2020		
				Expected	Actual				Expected	Actual	
<b>Emergency surgery</b>											
Fasciotomy	1,114	936	1,114	1,110.7	1,176	1,661	1,659	1,903	1,983	1,989	–2.1
			(1,063.9–1,158.6)						(1,967.7–2,102.8)		(–5.4 to 1.0)
Reduction of dislocated joint	28,391	25,867	24,269	22,351.7	20,264	46,212	42,241	39,625	36,573.9	36,422	–0.4
			(22,157.6–22,545.9)						(36,296.5–36,811.6)		(–1.1 to 0.3)
<b>Infection surgery</b>											
Osteomyelitis, Osteoabscess	2,043	2,139	2,251	2,354.5	2,379	3,658	3,626	4,033	4,222.6	4,153	–1.6
			(2,284.8–2,426.6)						(4,129.8–4,319.3)		(–3.8 to 0.6)
Synovectomy	13,518	14,496	14,496	50,552	15,705	21,301	22,593	24,010	25,402.6	25,979	2.3
			(15,148.3–15,887.6)						(25,162.5–25,642.7)		(1.3–3.2)
<b>Trauma surgery</b>											
Open reduction and internal fixation	40,536	43,095	43,095	45,723.8	44,977	73,271	75,329	81,674	86,002.7	83,481	–2.9
			(45,120.5–46,370.2)						(85,512.7–86,411.1)		(–3.3 to –2.4)
External fixation	2,277	1,965	1,611	1,351.6	1,412	3,601	2,930	2,712	2,337.7	2,633	12.6
			(1,309.7–1,395.1)						(2,280.8–2,397.4)		(9.8–15.4)
Hemiarthroplasty of hip	3,301	3,503	3,572	3,700.6	3,808	5,787	6,241	6,647	7,099.0	7,237	1.9
			(3,614.9–3,789.9)						(6,972.7–7,225.3)		(0.2–3.8)

**Table 3.** Continued

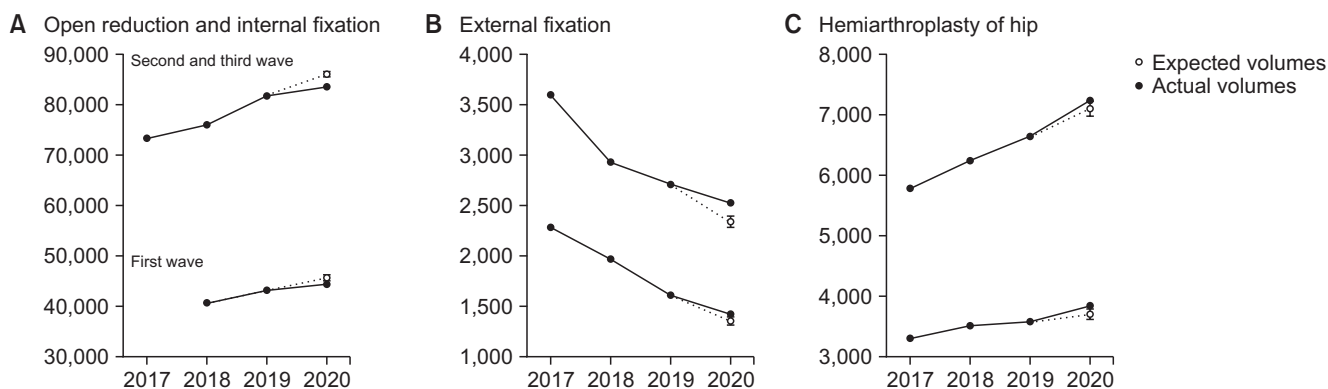
Variable	During the first wave (February–April, n)					During the second and third waves (August–December, n)					
	2017	2018	2019	2020		2017	2018	2019	2020		Diff, %*
				Expected	Actual				Expected	Actual	
Elective surgery											
Total hip arthroplasty	2,923	2,647	3,107	3,197.1	3,178	4,420	4,805	5,492	6,107.1	5,767	-5.6
				(3,116.3–3,281.0)					(5,986.3–6,227.9)		(-3.7 to -7.4)
Total knee arthroplasty	24,953	22,901	27,531	28,880.0	20,695	36,842	39,745	44,371	48,541.9	41,298	-14.9
				(28,632.2–29,127.8)					(48,231.3–48,896.8)		(-14.4 to -15.5)
Cruciate ligament reconstruction	3,550	3,358	3,647	3,683.5	3,250	5,663	5,817	6,111	6,324.9	5,063	-20.0
				(3,599.6–3,771.0)					(6,214.9–6,441.0)		(-21.4 to -18.5)
Rotator cuff repair	16,855	17,194	17,884	18,366.9	19,444	25,236	26,493	28,927	30,894.0	29,500	-4.5
				(18,170.1–18,563.6)					(30,633.7–31,154.4)		(-5.3 to -3.7)

Values are presented as the number of each surgical procedure.

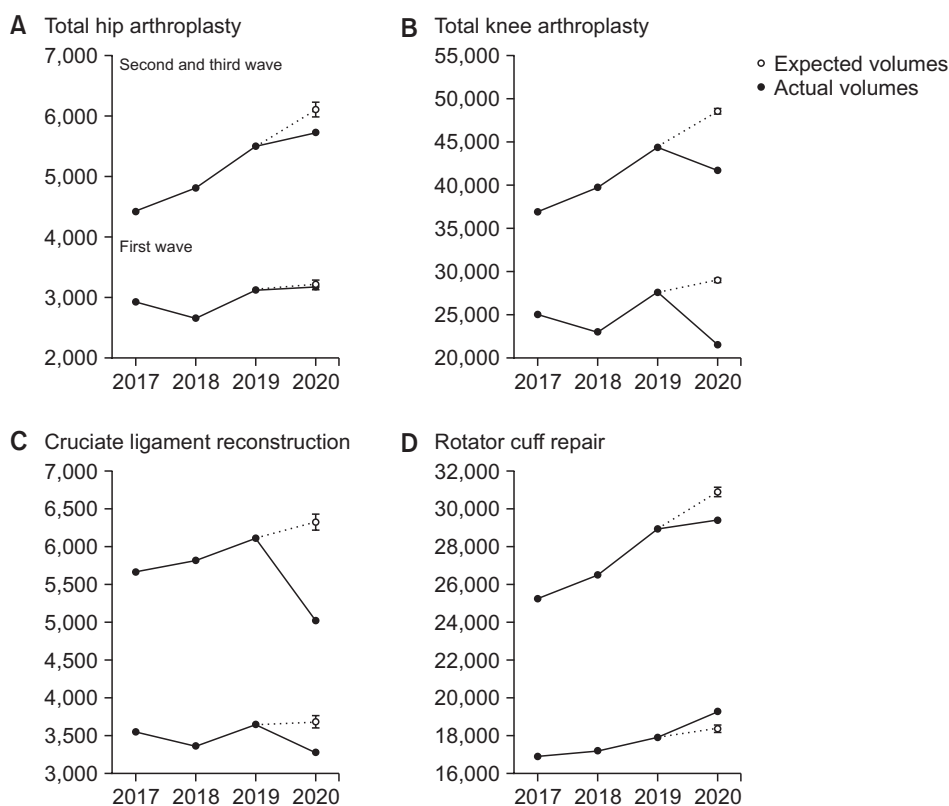
Ninety-five percent confidence intervals of the expected surgical number are expressed in parentheses.

COVID-19: coronavirus disease 2019. Diff: difference.

\*Difference between the expected and actual numbers of each surgical procedure.



**Fig. 3.** The volumes of trauma-related orthopedic surgery cases during the waves of coronavirus disease 2019 (COVID-19). (A) Open reduction and internal fixation. (B) External fixation. (C) Hemiarthroplasty of hip. Opened figure, expected volumes of surgery, Closed figure, actual volumes of surgery.



**Fig. 4.** The volumes of elective orthopedic surgery cases during the waves of coronavirus disease 2019 (COVID-19). (A) Total hip arthroplasty. (B) Total knee arthroplasty. (C) Cruciate ligament reconstruction. (D) Rotator cuff repair. Opened figure, expected volume of surgery, Closed figure, actual volumes of surgery.

after the COVID-19 outbreak.<sup>5,21,22)</sup> One study reported that surgery decreased by more than 50% compared to previous years.<sup>22)</sup> The reduced trauma volume significantly increased after lifting the lockdown.<sup>21)</sup> However, our findings show that trauma surgery, especially ORIF, was even getting worsened over time. This might be explained as follows: the COVID-19 outbreak in South Korea was localized in Dae-gu City and neighboring areas in the first wave.<sup>23)</sup> In addition, lockdown was not imposed except for social distancing to control COVID-19. For this reason, the volume of trauma surgery did not significantly de-

crease in the nationally registered data. After COVID-19 spread across the country during the second and third waves, the volume of trauma surgery decreased more than those in the first wave. However, the volume of HA surgery did not decrease over time. Among patients with orthopedic trauma, elderly patients ( $\geq 65$  years) accounted for the largest proportion after the COVID-19 outbreak.<sup>12)</sup> Moreover, the volume of hip fractures did not decrease even after the COVID-19 outbreak.<sup>24)</sup> Our findings are consistent with those of previous studies.<sup>12,24)</sup> Although the COVID-19 pandemic and social distancing affected the



total volume of orthopedic trauma, it did not have a significant effect on the incidence of fractures in the elderly, which occurred mainly at home. In addition, the volume of EF surgery increased over time. Although traffic accidents decreased, motorcycle accidents increased because the number of deliveries by motorcycles increased after the COVID-19 outbreak.<sup>25)</sup> In addition, the number of fatalities in motorcycle accidents increased by 4% compared to that in 2019.<sup>25)</sup> This might have contributed to the increased volume of EF surgeries. However, public interest in sports activities and sports-related surgery, such as CLR and RC repair, dramatically decreased after the COVID-19 outbreak.<sup>8,26)</sup> In addition, physical activity has decreased worldwide, including in South Korea.<sup>27)</sup> Therefore, the number of CLR surgeries gradually decreased over time. In terms of degeneration-related surgery, total joint arthroplasty (TJA) also dramatically decreased in the early stages of the COVID-19 outbreak.<sup>2,4,11,26,28)</sup> However, 54% of patients with hip or knee arthritis experienced worsening pain after their surgery was canceled.<sup>4)</sup> Some patients even wanted to undergo TJA despite the risk of contracting COVID-19 due to aggravated pain.<sup>4)</sup> These factors might have contributed to the resuming of TJA surgery.<sup>17,28)</sup> In our study, TKA showed a resuming pattern, which is in line with previous studies; however, THA did not.<sup>17,28)</sup> THA can be performed for various reasons, such as primary hip osteoarthritis, posttraumatic osteoarthritis, hip fracture, avascular necrosis, and rheumatoid arthritis.<sup>29,30)</sup> Primary hip osteoarthritis accounts for the majority of THA cases in Western countries.<sup>29)</sup> However, the most common cause of THA in South Korea is avascular necrosis, and the proportion of hip fractures remains small.<sup>30)</sup> The discrepancy in the epidemiology of THA between Western countries and South Korea might have affected the differences in recovery patterns.

This study has several limitations. First, the accurate diagnosis that led to each surgical procedure could not be obtained from the HIRA data. This study was conducted based on the procedure codes claimed by the HIRA. There seems to be a discrepancy between the accurate diagnosis and the claimed procedure code. In addition, the data were collected from only one nation. However, this study was meaningful in showing the trend of changes in the volumes of orthopedic surgery over time during the COVID-19 pandemic for one year. Second, a Poisson regression model was used to predict the surgical volume. The period included in the study was relatively short, as some of the extracted data from the HIRA were not available. If the period could have been extended, the results might have been different. However, analysis using a predictive model

seemed to be more clinically meaningful than comparing it with the previous average volumes of surgery, because it could reflect the annual increase or decrease each year. Third, the study included only the period before the COVID-19 vaccination. Vaccination is known to effectively protect people against COVID-19, which also affects the changes in the government's quarantine guidelines and people's perceptions about COVID-19. Thus, the trend of orthopedic surgery may change again after COVID-19 vaccination is carried out earnestly.

In conclusion, the reduced number of orthopedic surgeries due to the COVID-19 pandemic tended to recover over time in South Korea. However, the trend of change in surgical volume depended on surgical categories. Significantly reduced elective surgery resulted in the recovery of the volumes of surgery. However, the number of trauma surgeries did not decrease, even during the first wave of COVID-19. Among the trauma and elective surgeries that accounted for the majority of orthopedic surgeries, the reduced volume of degeneration-related surgeries such as TKA recovered over time. Although outside activity-related surgery, such as ORIF and CLR, decreased over time, the volume of fractures in the elderly was maintained even during the second and third waves of COVID-19. The findings of our study may help estimate the burden of orthopedic surgery in the era of persistent COVID-19.

## CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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