

The COVID-19 Pandemic Consequences on Microsurgical Reconstructions: A Single Center's Shift of Indications

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Background: Since its outbreak, the COVID-19-pandemic has had a tremendous impact on healthcare systems worldwide. We conducted a comparative study to analyze the pandemic's consequence on microsurgical reconstructions at a reconstructive plastic surgery center in Sweden.

Method: All free flaps performed at a single center between March 2019 and 2021 were analyzed. The patient cohort was divided into two groups, with a period of 1 year in each group: non-COVID-19 year and COVID-19 year. The periods were compared regarding the number and type of surgeries and patient characteristics.

Results: In the year prior to the pandemic, 123 free flap surgeries were performed, compared with 103 surgeries during the COVID-19 year. There was a significant shift in the most common site for free flap reconstruction: from the breast [which decreased by 42% (66–38)] to head and neck [which increased by 22% (41–50); OR 0.53 ($P=0.02$)]. This was also reflected by a significant increase in hospital stay for free flap patients during the COVID-19 year ($P=0.02$).

Conclusions: During the COVID-19 pandemic, a shift was seen from breast reconstructions toward head and neck reconstructions as the most common free flap procedure performed. An increasing backlog of elective breast reconstructions demands increased resources and tougher priorities, which challenge the healthcare system in the post-COVID-19 era. (*Plast Reconstr Surg Glob Open* 2022;10:e4309; doi: [10.1097/GOX.0000000000004309](https://doi.org/10.1097/GOX.0000000000004309); Published online 25 April 2022.)

INTRODUCTION

Autologous free tissue transfer is a valuable technique for the reconstruction of imperative cancer cases and acute trauma wounds, and for a wide range of secondary reconstructions. However, microsurgical procedures require ample resources, with comparably long operation hours and extended patient admission time in the postoperative ward.

Since the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) outbreak, healthcare systems worldwide have been affected. By March 11, the World Health Organization characterized the spread of coronavirus

disease 2019 (COVID-19) as a pandemic.¹ It has been estimated that during a 12-week peak of COVID-19 in spring 2020, 72% of planned surgeries were canceled or postponed worldwide.² Sweden is no exception, as evident in the report from the National Board of Health and Welfare of Sweden. From the beginning of March 2020, when the first wave of the COVID-19 pandemic started in Sweden, until August 2020, the number of surgeries and other medical treatments decreased by 31%, and secondary care visits decreased by 14%, compared with those during the same period in previous years. Primary care visits during March through May 2020 decreased by 15% compared with those during January–February 2020.³ Furthermore, there have been reports about patient delay in cancer care and, consequently, possibly more advanced stages of cancer at diagnosis due to the COVID-19 pandemic.^{4,5}

Reports from microsurgical departments of disruptive effects of the pandemic have also been published. Studies have revealed divergence from standard clinical practices; some institutions have continued free tissue transfers, some on a limited basis, whereas others had halted it completely, and new protocols have been suggested.^{6–10} Data from the United Kingdom have shown a reduced number

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Received for publication December 20, 2021; accepted March 8, 2022.

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DOI: [10.1097/GOX.0000000000004309](https://doi.org/10.1097/GOX.0000000000004309)

Disclosure: The authors have no financial interest to declare in relation to the content of this article.

of autologous breast reconstructions a few months into the pandemic, compared with the same period during the previous year.^{10,11} We sought to investigate how the COVID-19 pandemic has affected microsurgical operations in terms of the number of surgeries and the patient population receiving a microsurgical reconstruction at a single center in Sweden, and compare these aspects with those during a normal year prior to the pandemic.

MATERIALS AND METHODS

A retrospective cohort study was conducted, including all consecutive free flap cases at Karolinska University Hospital, Stockholm, Sweden, over 2 years, March 2019–March 2021. The study was approved by the Regional Ethics Committee Stockholm, Dnr 2006/834-31 Amd 2016/1578-32. Also, the study was completed in accordance with the World Medical Association Declaration of Helsinki.

Data regarding patient characteristics [including age, sex, smoking habits, body mass index (BMI), comorbidities, and type of reconstruction] were retrieved from hospital medical records, as were TNM classification for cancer reconstructions. Demographic data are presented for each patient, and the number of free flaps is the total number of free flaps performed. T-classification T4a and T4b, N-classification N2a and N2b, and N3a and N3b were grouped into T4, N2, and N3, respectively.^{12,13} To illustrate the changes in the COVID-19 pandemic, data regarding the number of COVID-19-related intensive care unit (ICU) admissions in the region of Stockholm were taken from the COVID-19 pandemic's statistic page by the Public Health Agency of Sweden.¹⁴

Patients were divided into two groups to compare the year affected by the COVID-19 pandemic to the prior year. The pandemic year was considered to have begun on March 15 because all elective surgeries were canceled at the plastic and reconstructive surgery department at Karolinska University Hospital at this date. Therefore, the non-COVID-19 year was from March 15, 2019, to March 14, 2020, and the COVID-19 year was from March 15, 2020, to March 14, 2021. To further study temporal trends in surgical activity, the non-COVID-19 and the COVID-19 year were divided into four time periods, representing a quarter of a year in each period.

The results are presented as median and percentiles for continuous variables and percentages for categorical variables. Comparisons between the non-COVID-19 and COVID-19 years were made with Mann-Whitney U test for continuous variables, chi-squared test for categorical variables; for the analysis between subset groups of the variables, a one-way analysis of variance test was conducted. A subgroup analysis for the two largest groups of reconstructions was performed: head and neck reconstruction (HNR) and breast reconstruction (BR). Due to the small size of the groups, no subgroup analysis was performed for the extremity reconstruction (ER) group. For the BR-subgroup, gender was excluded from the statistical analysis because BR contained only women, as was smoking, which is because smoking cessation is a prerequisite

Takeaways

Question: Did the first year of the COVID-19 pandemic affect microsurgical reconstructions?

Findings: The number of free flap surgeries decreased the first year of the COVID-19 pandemic from 123 surgeries the year prior to 103 surgeries. There was a significant shift in the most common site for free flap reconstruction from breast, which decreased by 42%, to head and neck, which increased by 22%, OR 0.53 ($P = 0.02$).

Meaning: By reallocation of available health care resources (including medical staff), imperative microsurgery has remained unaffected by the pandemic. In the future, a backlog of elective breast reconstructions will demand increased resources and tougher priorities.

for BR. A P value of less than 0.05 was considered significant. All statistical analyses were performed using IBM SPSS Statistics 27.0 software for Windows 10 (Microsoft Corp, Redmond, Wash.).

RESULTS

In total, 226 microsurgical free flaps were performed over a 2-year period at Karolinska University Hospital. During the year prior to the COVID-19 pandemic, 123 microsurgical free flap surgeries were performed, compared with 103 during the COVID-19 year (Fig. 1). There was a significant shift in the most common site for free flap reconstruction, from the breast [which decreased by 42% (66–38 free flaps)] to the head and neck [which increased by 22% (41–50 free flaps); OR 0.53 ($P = 0.02$)]. During the COVID-19 pandemic year, days hospitalized in connection to the surgery significantly increased compared with the same during the previous year ($P = 0.02$) (Table 1). The dominant free flap-type for the non-COVID-19 year was the DIEP flap, which amounted to 50.4% of the flaps when compared with 34% during the COVID-19 year (Table 1).

One of the 103 patients who underwent free flap surgeries (0.97%) during the COVID-19 year was COVID-19 positive in the perioperative period. The patient developed nausea and fever 19 days after a fibula flap reconstruction surgery and tested positive for COVID-19 21 days after the surgery. The patient was admitted for another 18 days, but the COVID-19 symptoms subsided after just a few days.

Temporal Trends in Free Flap Reconstruction Surgeries

In Figure 2, the temporal trends of the number of surgeries during the 2 years are shown. An inverse relationship was seen between ICU admissions and free flap-cases performed, mainly reflecting the allocation of anesthesia resources from elective surgery to COVID-19-related care.² During the non-COVID-19 pandemic year, normal seasonal variations are evident in the number of surgeries performed. When comparing the non-COVID-19 year with the COVID-19 year, a large drop can be seen in the number of surgeries performed during the first few months of the COVID-19 pandemic year. When the number

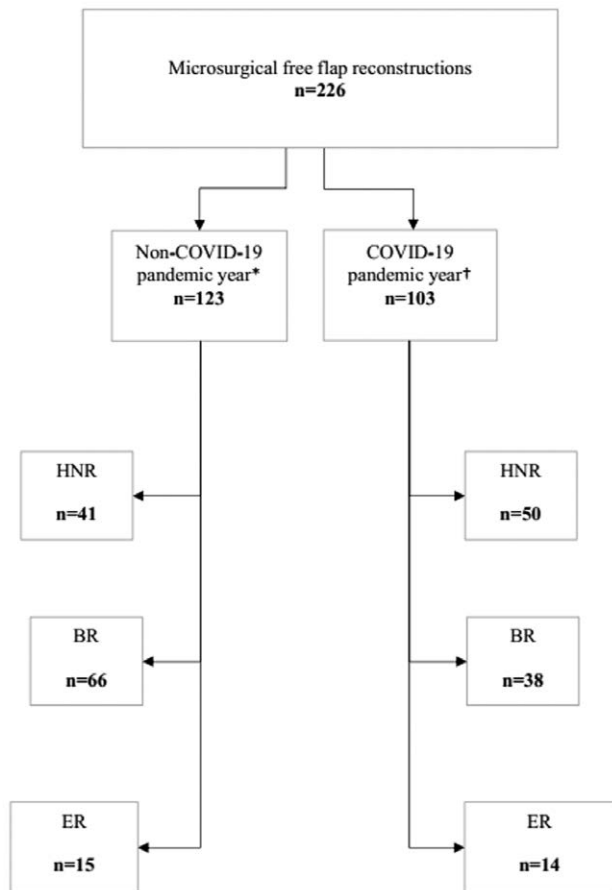


Fig. 1. Flowchart of the microsurgical free flaps performed. *March 15, 2019–March 14, 2020. †March 15, 2020–March 14, 2021. n, number of microsurgical free flap reconstructions.

of COVID-19-related ICU admissions in the region of Stockholm started to subside, the number of surgeries increased to an average level at the department during the summer months. During the fall, the number of microsurgical free tissue transfers surpassed those during the previous non-COVID-19 year (Fig. 2). With the start of the second pandemic wave, surgeries again decreased, but to a similar level as that of the previous year. As for the HNR subgroup, there was a slight decrease in the number of reconstructions performed during the first period, representing the first 3 months of the pandemic. In the following three periods, the number of surgeries had increased compared with the non-COVID-19 year (Fig. 3A). In the BR-subgroup, it is possible to follow the variations of the pandemic (Fig. 3B). During the first three months of the pandemic (period 1), all BRs were canceled or postponed. In period 4, there is a drop again, representing the second wave of the pandemic in Sweden. Reconstruction of the extremities did not follow any noticeable trend and did not reflect the COVID-19 pandemic's periodic changes.

Head and Neck Reconstructions

In the HNR group, there were no significant differences in patient characteristics between the 2 years

Table 1. Patient Characteristics for Free Flap Reconstructions

	Non-COVID-19 Year (n = 114)	COVID-19 Year (n = 95)	P
Gender, women	76 (66.7)	52 (54.7)	0.08
Age, y	53 (46–63)	60 (46–68)	0.28
BMI	21.3 (19.9–23.1)	22.1 (20.1–23.7)	0.17
Smoking	8 (7.0)	9 (9.5)	0.52
Cardiovascular disease*	32 (28.1)	34 (35.8)	0.23
ASA classification			
1	24 (21.1)	14 (14.6)	
2	66 (57.9)	52 (54.7)	0.08
3	24 (21.1)	29 (30.5)	
Flap type			
DIEP	62 (50.4)	35 (34)	
Radial forearm	17 (13.8)	27 (26.2)	
ALT	12 (9.8)	15 (14.6)	
SCIP	1 (0.8)	1 (1.0)	
Fibula	19 (15.4)	14 (13.6)	
Other†	13 (9.7)	11 (10.6)	
Days hospitalized	8 (6–16)	15 (6–17)	0.02

Median value and 25th–75th percentile are presented for continuous variables and percentage for categorical variables, and number of cases and percentage for categorical variables.

*Acute myocardial infarction, stroke, peripheral vascular disease, hypertension, or diabetes mellitus.

†Gracilis, latissimus dorsi, transverse musculocutaneous gracilis, scapula, rectus abdominis, vastus lateralis, and profunda artery perforator. ALT, anterolateral thigh; ASA, American Society of Anesthesiologists; DIEP, deep inferior epigastric perforator; n, number of patients; SCIP, superficial circumflex iliac artery perforator.

(Table 2). Regarding the flap type used, the radial forearm flap increased from 39% to 52% during the pandemic year, whereas the fibula flap decreased from 44% to 24%. However, these differences were nonsignificant. When looking at TNM characteristics, we could see an increasing trend in free flap reconstruction in smaller tumors that corresponds to a lower T-stage, but this difference did not reach statistical significance ($P = 0.07$) (Table 2).

Breast Reconstructions

Patient characteristics for the BR group are presented in Table 3. During the COVID-19 pandemic year, the free flap BR patients were significantly younger compared with those from the previous year; median age during the non-COVID-19 year was 52 years (25th–75th percentile 45–57.5), whereas the COVID-19 year median age was 49 years (25th–75th percentile 45–51 [$P = 0.04$]) (Table 3).

DISCUSSION

To our knowledge, this is the first study presenting how the COVID-19 pandemic influenced microsurgical activity in actual numbers of surgeries performed and the patient cohort receiving surgery compared with a non-COVID-19 affected year. During the first year of the COVID-19 pandemic, a decrease in the total number of free flap reconstructions was seen, from 123 surgeries in the non-COVID-19 year to 103 during the COVID-19 pandemic. This decline could be explained by a considerable reduction in autologous BR, reflecting that mainly secondary breast reconstructions are performed at our unit. On the other hand, we could see an increase in the numbers of HNR, but the number of extremity reconstructions stayed at a constant level. The latter two being mainly imperative surgeries, it is relieving to see that, despite the tremendous

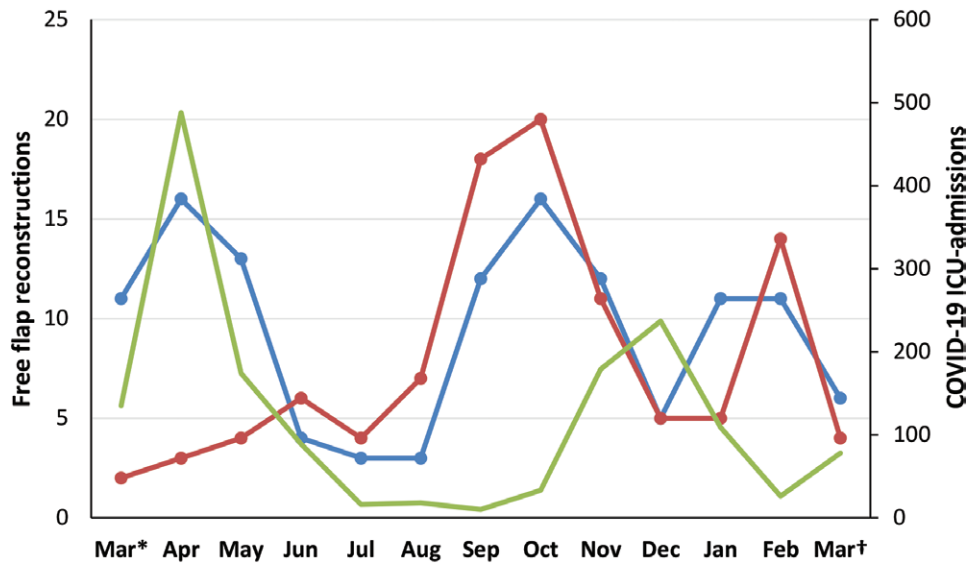


Fig. 2. Temporal trends in free flap reconstructions performed and ICU admissions during the non-COVID-19 and the COVID-19 year. Number of microvascular free flaps performed during the non-COVID-19 year, March 15, 2019–March 14, 2020 (blue) and COVID-19 year, March 15, 2020–March 14, 2021 (red) and ICU admission at the regions of Stockholm from March 15, 2020–March 14, 2021 (green). Total number of surgeries performed and ICU admission per month. *Starting March 15. †Ending March 14.

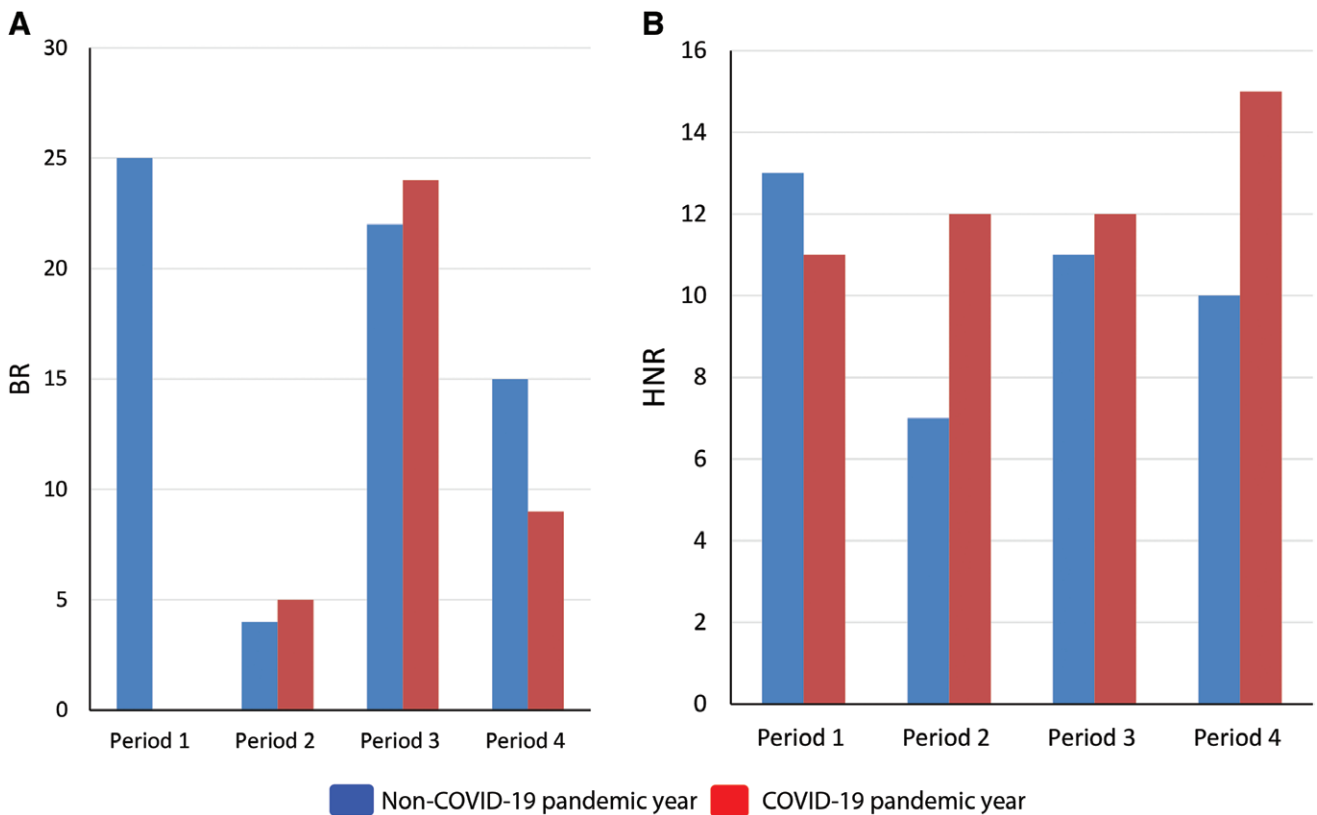


Fig. 3. Number of breast and head and neck free flap reconstructions performed during the non-COVID-19 and the COVID-19 year. Number of microvascular breast reconstructions (A) and head and neck (B) reconstructions performed during the non-COVID-19 year (blue) and COVID-19 year (red) and divided into four periods, representing a quarter of a year in each period. Period 1: 15th of March to the 14th of June; Period 2: 15th of June to the 14th of September; Period 3: 15th of September to the 14th of December; and Period 4: 15th of December to the 14th of March.

Table 2. Patient and Tumor Characteristics for Head and Neck Reconstructions

	Non-COVID-19 Year (n = 41)	COVID-19 Year (n = 50)	P
Gender, women	16 (39.0)	8 (36.0)	0.77
Age, y	67 (52–74)	65 (61–71)	0.79
BMI	21.5 (18.5–23.7)	21.9 (19.4–26.6)	0.64
Smoking	8 (19.5)	8 (16.0)	0.66
Cardiovascular disease*	23 (56.1)	25 (50.0)	0.56
ASA classification			
1	7 (17.1)	3 (6.0)	
2	14 (34.1)	22 (44.0)	0.39
3	20 (48.8)	25 (50.0)	
Flap type			
Radial forearm	16 (39.0)	26 (52.0)	
ALT	6 (14.6)	11 (22.0)	0.24
Fibula	18 (43.9)	12 (24.0)	
Rectus abdominis	1 (2.4)	1 (2.0)	
Days hospitalized	17 (16–19)	17 (15–19)	0.93
TNM classification			
T-stage			
1	1 (3.3)	4 (9.8)	
2	5 (16.7)	11 (26.8)	0.07
3	8 (26.7)	12 (29.3)	
4	16 (53.3)	14 (34.1)	
N-stage			
0	18 (60.0)	28 (68.3)	
1	3 (10.0)	5 (12.2)	0.29
2	6 (20.0)	6 (14.6)	
3	1 (3.3)	1 (2.4)	
Unknown	2 (6.7)	1 (2.4)	
M-stage			
0	27 (90)	39 (95.1)	
1	0 (0.0)	0 (0.0)	0.41
Unknown	3 (10.0)	2 (7.0)	

Median value and 25th–75th percentile are presented for continuous variables and percentage for categorical variables, and number of cases and percentage for categorical variables.

*Acute myocardial infarction, stroke, peripheral vascular disease, hypertension, or diabetes mellitus.

ALT, anterolateral thigh; ASA, American Society of Anesthesiologists; n, number of patients; TNM, tumor (T), nodes (N), and metastases (M).

burden on the healthcare system the past year, these vital operations have not been affected to a larger extent. As an accredited comprehensive cancer center, our hospital has had a high volume of cancer care throughout the pandemic, but most elective care has been halted during the

Table 3. Patient Characteristics for Breast Reconstructions

	Non-COVID-19 Year (n = 57)	COVID-19 Year (n = 30)	P
Age, y	52 (45–57.5)	49 (45–51.3)	0.04
BMI	21.3 (20.4–22.4)	22.4 (20.3–23.0)	0.18
Cardiovascular disease*	5 (8.8)	4 (13.3)	0.51
ASA classification			
1	12 (21.1)	8 (26.7)	
2	45 (78.9)	21 (70.0)	0.82
3	0 (0.0)	1 (3.3)	
Bilateral reconstructions	9 (15.8)	8 (26.7)	
Flap type			
DIEP	62 (93.9)	35 (92.1)	
SCIP	1 (1.4.6)	0 (0.0)	
TMG	3 (4.5)	1 (2.6)	
PAP	0 (0.0)	2 (5.3)	
Days hospitalized	6(5–7)	5(5–6)	0.15

Median value and 25th–75th percentile are presented for continuous variables, and number of cases and percentage for categorical variables.

*Acute myocardial infarction, stroke, peripheral vascular disease, hypertension, or diabetes mellitus.

DIEP, deep inferior epigastric perforator; n, number of patients; PAP, profunda artery perforator; SCIP, superficial circumflex iliac artery perforator; TMG, transverse myocutaneous gracilis.

peaks of COVID-19. The medical staff has been reallocated to departments with the greatest needs. Many plastic surgeons were relocated to work in the ICU and emergency department, and the plastic surgery ward was changed to a COVID-19 patient ward with plastic surgeons and nurses in charge of the medical care. However, imperative cancer- and trauma-reconstructions have been performed and treated within other surgical facilities and wards with plastic surgeons as consultants. The shift toward a larger proportion of HNR has required a broad surgical knowledge among plastic surgical colleagues, being able to change from one's ordinary area of expertise. Increased competence as backup during weekends has also been necessary with longer monitoring times because most of the BR re-explorations happen within the 24 hours after surgery, and it is well known that HNRs, to a larger extent, have a risk for complications needing re-exploration during a more extended period after the surgery.^{15,16} The significantly longer hospitalization also reflects the shift toward a larger proportion of HNR during the COVID-19 year. To not compromise the care of the patients receiving free flap reconstructions, our standard postoperative protocols, including our limited use of antithrombotic agents to prevent postoperative hematoma formation, were used for these surgeries throughout the first pandemic year.¹⁷

Head and Neck Reconstructions

In our study, we could see an increase in HNR during the COVID-19 year. During the spring and summer of 2020, just a few months after the start of the pandemic, both national and international reports about a decline in the number of newly diagnosed cancer cases started to be published.^{4,18} In Sweden, newly diagnosed tumors (all cancer types) decreased by 9% from January to October 2020, compared with those during the prior year. The largest drop in diagnosed cancer cases was seen in the first months of the pandemic, and then it gradually increased during the fall of 2020 to a level similar to that of the previous year.⁵ The decrease may partly be explained by quarantine restrictions that hampered routine healthcare check-ups for high-risk groups due to the health care system's decreased ability to investigate suspected cancers and perform screening. The delay in cancer diagnosis could lead to a more severe cancer at diagnosis and, theoretically, to an increase in the number of cases needing a free flap reconstruction—that is, explaining at least part of the increased number of HNRs seen during the three later periods of the COVID-19 year. Another potential explanation could be a change to a broader indication for free flap HNR surgery, reflected by an increase in radial forearm flaps (ie, smaller reconstructions) in both actual numbers (from 16 to 26 cases) and in percent of all HNRs (from 39% to 52%) during the COVID-19 year. A trend toward lower T-stages (smaller tumors) receiving HNR during the COVID-19 year compared with those during the prior year could potentially also support a broader surgical indication for free flap HNR. However, neither the change in flap-type nor T-stage yielded statistically significant results in our subgroup analysis. However, the small patient population in the present study makes it difficult

to draw any conclusion regarding the actual increase in reconstructions and the potential explanations.

Breast Reconstructions

The reduced number of autologous BRs seen during the COVID-19 year (from 66 the year before COVID-19 to 38 in the COVID-19 year) was expected because a vast majority of them are performed as elective surgery in a secondary setting at our hospital. This reduction is in line with the results recently presented by Hemal et al⁹ The largest difference is seen in period 1, representing the first wave of the COVID-19 pandemic in Stockholm when all autologous BR surgeries were canceled. The second COVID-19 wave in Sweden seen during period 4 in [Figure 2C](#) also shows a reduction in the number of surgeries, but not as severe as the first wave. During the second COVID-19 wave, the region of Stockholm was not affected as severely as during the first wave.¹⁹ This, combined with increased knowledge about SARS-CoV-2 and more prepared health-care, could probably explain the continued BR activity during the later COVID-19 waves. Also, throughout the third COVID-19 wave in Sweden, during spring 2021, the autologous BR surgeries continued at our department (data not presented in this study). Nevertheless, the canceled surgeries have increased the future surgical load on the department, and much work is left to reduce surgical queues.

In the BR-subgroup analyses, age decreased significantly from the non-COVID-19 year to the COVID-19 year (median age 52 years [25th–75th percentile 45–57] to 49 years [25th–75th percentile 45–51] $P = 0.04$). Presumably, this is not because of the COVID-19 pandemic. This most likely reflects the backlog of hereditary high-risk breast cancer patients in need of surgery during the second half of the COVID-19 year.

Extremity Reconstructions

The number of free flap extremity reconstructions was similar between the non-COVID-19 year and the COVID-19 year: 15 and 14 cases, respectively. One might assume that there were fewer severe traumas in countries with rigorous COVID-19 rules and curfews, secondarily leading to a decrease in extremity reconstruction. However, Campbell et al reported only a minimal decrease in open lower limb fractures during the first lockdown period in the United Kingdom.²⁰ Sweden, where the present study comes from, has had fewer restrictions than other countries, and used restrictions have only been recommended, but not considered mandatory. Furthermore, no curfews have been used; therefore, no reduction in trauma cases is expected.

SARS-CoV-2 Infections

In the present study, only one patient was diagnosed with COVID-19 in the perioperative period to the microvascular surgery, 21 days after the surgery. This patient had an HNR due to cancer, and the patient did not suffer any minor or major complications secondary to the COVID-19 infection. The COVIDSurg Collaborative study showed that half of the patients diagnosed with SARS-CoV-2 in the perioperative period had a pulmonary complication, and

there was a high risk of mortality.²¹ However, in a multi-center study from the United Kingdom and Ireland, 19 of the 418 patients undergoing major reconstructive surgery were COVID-19 positive. The study showed patient safety and postoperative outcome equivalent to the results presented before the COVID-19 outbreak.²² A preoperative PCR-test of SARS-CoV-2 1–3 days before planned surgery could explain a low rate of COVID-19-positive patients in our cohort. All patients with a positive test but without symptoms were postponed for 14 days, and patients with symptoms were postponed 14 days after the last symptom had subsided. Major cancer surgeries, where treatment could not be delayed without an increased risk for the patient, were excluded from this rule. In the present study, no patient underwent surgery with a preoperative positive COVID-19 test. However, we do not have data on whether elective surgeries were postponed due to a positive test.

LIMITATIONS

The retrospective nature and the limited number of patients in the present study make it difficult to draw generalized conclusions. The COVID-19 pandemic has affected the healthcare systems in different countries, and even in different cities in the same country, to a variable extent. A multicenter study would be preferable to get a broader picture of the effect of the pandemic on microsurgical reconstruction. However, our result provides an insight into the pandemic's impact on plastic surgery departments and the reconstructive care.

CONCLUSIONS

Despite the tremendous effect the COVID-19 pandemic has had on healthcare systems worldwide, it seems like the imperative reconstructive plastic surgery activity has remained unaffected at the current center. We believe that the combination of reallocation of broadly trained medical staff, a solid routine for preoperative COVID-19 testing, and prioritizing imperative care has been the keystone for this result. The shift of indications for microsurgery has required a broad surgical knowledge among plastic surgical colleagues, being able to change from one's ordinary area of expertise. The achieved broader competence within the microsurgical team will also be of value for on calls and holiday seasons, where imperative surgery may be indicated when the ordinary staff is unavailable. Elective surgery, mainly represented by BR in the present study, has been halted, and we are facing major challenges to catch up with the current backlog. This will lead to either restrictions in indications for secondary free flap breast reconstruction or an increased need for resources to tackle the current backlog.

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ACKNOWLEDGMENT

We offer our special thanks to the statistician Johan Zetterqvist, at the Department of Learning, Informatics, Management and

Ethics, Karolinska Institute, for his excellent advice and help with the statistics.

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