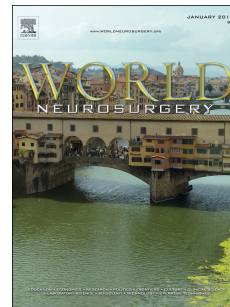# Journal Pre-proof

CSF rhinorrhoea after endonasal intervention to the skull base (CRANIAL).

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CSF rhinorrhoea after endonasal intervention to the skull base (CRANIAL). Part 2: Impact of COVID-19

Authors list

CRANIAL Consortium

Soham Bandyopadhyay*, Danyal Z Khan*, Hani J Marcus, Benjamin E Schroeder, Vikesh Patel, Alice O'Donnell, Shahzada Ahmed, Andrew F Alalade, Ahmad MS Ali, Callum Allison, Sinan Al-Barazi, Rafid Al-Mahfoudh, Meriem Amarouche, Anuj Bahl, David Bennett, Raj Bhalla, Pragnesh Bhatt, Alexandros Boukas, Ivan Cabrilo, Annabel Chadwick, Yasir A Chowdhury, David Choi, Simon A Cudlip, Neil Donnelly, Neil L Dorward, Graham Dow, Daniel M Fountain, Joan Grieve, Anastasios Giamouriadis, Catherine Gilkes, Kanna Gnanalingham, Jane Halliday, Brendan Hanna, Caroline Hayhurst, Jonathan Hempenstall, Duncan Henderson, Kismet Hossain-Ibrahim, Theodore Hirst, Mark Hughes, Mohsen Javadpour, Alistair Jenkins, Mahmoud Kamel, Richard J Mannion, Angelos G Kolias, Habibullah Khan, Mohammad Saud Khan, Peter Lacy, Shumail Mahmood, Eleni Maratos, Andrew Martin, Nijaguna Mathad, Patrick McAleavey, Nigel Mendoza, Christopher P Millward, Showkat Mirza, Sam Muquit, Daniel Murray, Paresh P Naik, Ramesh Nair, Claire Nicholson, Alex Paluzzi, Omar Pathmanaban, Dimitris Paraskevopoulos, Jonathan Pollock, Nick Phillips, Rory J Piper, Bhaskar Ram, Iain Robertson, Elena Roman, Peter Ross, Thomas Santarius, Parag Sayal, Jonathan Shapey, Rishi Sharma, Simon Shaw, Alireza Shoakazemi, Saurabh Sinha, Georgios Solomou, Simon Stapleton, Patrick Statham, Benjamin Stew, Syed Shumon, Wai Cheong Soon, Nick Thomas, Georgios Tsermoulas, James R Tysome, Adithya Varma, Philip Weir, Adam Williams, Mohamed Youssef.
*Joint first authors who contributed equally

Affiliations

See Supplementary File 1

Correspondence

Hani J Marcus

National Hospital for Neurology and Neurosurgery &

Wellcome / EPSRC Centre for Interventional and Surgical Sciences, University College London

United Kingdom

Email: hani.marcus@ucl.ac.uk

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CSF Rhinorrhoea After Endonasal Intervention to the Skull Base (CRANIAL).
Part 2: Impact of COVID-19

Abstract

Background:

During the pandemic, there has been a concern about the increased risk of perioperative mortality for patients with COVID-19, and the transmission risk to healthcare workers, particularly during endonasal neurosurgical operations. The Pituitary Society produced recommendations to guide management during this era. We sought to assess contemporary neurosurgical practice and the impact of COVID-19.

Methods:

A multicentre, prospective, observational cohort study was conducted at twelve tertiary neurosurgical units (UK and Ireland). Data were collected from March 23rd-July 31st, 2020 inclusive. Data points collected were patient demographics, pre-operative COVID-19 testing, intra-operative operative modifications, and 30-day COVID infection rates.

Results:

124 patients were included. 116 patients (n=116/124, 94%) underwent COVID-19 testing pre-operatively (TSA: 97/105, 92%; EEA: 19/19, 100%). One patient (n=1/115, 1%) tested positively for COVID-19 pre-operatively, requiring a delay of operation until the infection was confirmed as resolved. Asides from transient diabetes insipidus; no other complications were reported for this case. All theatre staff wore at least level 2 PPE. Adaptations to surgical techniques included minimising drilling, draping modifications, and using nasal iodine wash. At 30 days postoperatively, there was no evidence of COVID infection (symptoms or on formal testing) in our cohort, and no mortality.

Conclusions:

Preoperative screening protocols and operative modifications have facilitated endonasal neurosurgery during the COVID-19 pandemic, with Pituitary Society guidelines followed for the majority of these operations. There was no evidence of COVID infection in our cohort, and no mortality, supporting the use of risk mitigation strategies to continue endonasal neurosurgery in subsequent pandemic waves.

Introduction

The COVID-19 pandemic is an ongoing global pandemic caused by a novel coronavirus (SARS-CoV-2) [1,2]. Measures were put in place to mitigate the spread of the virus, and thereby prevent national healthcare systems from being overwhelmed. These measures included re-enlisting retired healthcare workers [3] and redeploying surgeons to provide out-of-speciality care [4,5]. As a secondary consequence of this reallocation of resources in healthcare services globally, it proved increasingly challenging to continue providing existing services for other diseases and conditions. Noticeably, there was a reduction in surgical activity [6–8]. This is likely to have been compounded by the fact that there was initial concern that patients undergoing surgery would be an especially vulnerable group due to their risk of exposure [9], and as such a more cautious approach was taken with regards to surgery.

One such speciality that has seen their normal services disrupted is neurosurgery [10], with some countries reporting the cancellation of over half of all their indicated neurosurgical operations [11]. This has been particularly the case for pituitary surgery [12,13]. One factor that played a role here was the need to protect healthcare workers (HCWs) [10,12]. Transmission of the SARS-CoV-2 virus occurs primarily via large respiratory droplets containing the virus. Therefore, HCWs working in certain specialities and sub-specialities are considered high-risk due to frequent exposure to oronasal secretions [14]. This includes HCWs involved in pituitary surgery given the number of procedures where access is via the nasal cavity and the sphenoid sinus [15]. In order to manage risk to HCWs involved in those procedures, the Professional Education Committee of the Pituitary Society produced a set of comprehensive international guidance [12]. This included advising all patients to undergo COVID-19 screening pre-operatively, non-drill techniques, considerations for alternative approaches (e.g. transcranial), and for theatre staff involved in endoscopic or microscopic endonasal trans-sphenoidal approach (TSA) surgeries to wear at least level 2 personal protective equipment (PPE) [16,17].

Whilst caseloads in neurosurgery may have decreased, some operations have occurred over the course of the pandemic [18,19]. These operations are most likely to have occurred for patients needing emergency surgery [20]. This includes patients presenting with pituitary apoplexy, visual loss, malignant pathology, or significant endocrine disorders. However, there is a lack of published data regarding the number of neurosurgical operations that occurred, the indications for why they occurred, and the post-operative complications for the patients that underwent neurosurgical operations during the COVID-19 pandemic. This data is essential, especially to quantify the effects on those who underwent an endonasal operation in the context of a respiratory virus. Fortuitously, the timeline of a prospective multi-centre pilot study in the United Kingdom (UK) and Republic of Ireland - CSF rhinorrhoea after endonasal intervention to the skull base (CRANIAL) [21] – coincided with the start of the COVID-19 pandemic. This provided a unique opportunity to assess the effects of the COVID-19 pandemic on endonasal surgery practices in the UK in real-time. Therefore, this paper will primarily aim to capture whether advice regarding COVID-19 testing and PPE have been followed, the intra-operative adaptations to COVID-19, the 30-day post-operative COVID-19 infection rate, and the mortality rate.

Methods

Design

A multicentre, prospective, observational cohort study design was implemented [21] at twelve tertiary academic neurosurgical units where the CRANIAL network had been established prior: Aberdeen Royal Infirmary (Aberdeen, UK), Addenbrooke's Hospital (Cambridge, UK), Beaumont Hospital (Dublin, Ireland), Greater Manchester Neurosciences Centre (Salford, UK), John Radcliffe Hospital (Oxford, UK), National Hospital for Neurology and Neurosurgery (London, UK), Queen Elizabeth Hospital (Birmingham, UK), Royal Hallamshire Hospital (Sheffield, UK), Royal Victoria Hospital (Belfast, UK), Royal Victoria Infirmary (Newcastle-upon-Tyne, UK), Sheffield Children's Hospital (Sheffield, UK) and the Walton Centre (Liverpool, UK). The project was registered as a service evaluation at each centre – garnering approvals from audit departments (and Caldicott guardians when required). The local team consisted of consultant lead(s) with overall project responsibility, trainee lead(s) in charge of data collection and on occasion, student lead(s) for additional support. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement was used in the preparation of this section of the manuscript [22].

Eligible cases included patients of all ages undergoing TSA for sellar tumours and expanded endonasal approach (EEA) for skull base tumours [21]. Exclusion criteria were patients undergoing transcranial surgery and those with a history of preoperative CSF rhinorrhoea. Case selection was limited to those who presented between March 23rd and July 31st inclusive. Prior to March 23rd, there were pauses in data collection owing to data proforma amendments and attaining extra approvals (for example, information governance approvals where requested). This also allows for our data to coincide with when "lockdown began" in the UK [23].

Data collection

Data points collected were patient demographics, pre-operative COVID-19 status, operative modifications, and post-operative COVID-19 data. The primary outcomes of interest were: (1) COVID-19 pre-operative screening method (2) precautions taken to reduce the risk of airborne pathogen transmission; and (3) 30-day COVID-19 infection rate for patients post-operatively. Secondary outcomes of interest were: (1) length of hospital stay; and (2) mortality rate.

Local teams submitted data to a secure web-based central database hosted by Castor Electronic Data Capture (https://www.castoredc.com/). All initial data were collected within 30 days of operation, followed by a 30-day follow-up window. Data points collected by medical students or junior trainees were confirmed with operating surgeons or senior members of the team before the final submission into the Castor EDC system [21].

Data validation

Data validation was performed in all centres to audit quantitative data accuracy [21]. This involved an independent data validator (who did not collect local data) who reviewed datasets for several enrolled cases, selected randomly. This data validator was from the hospital in which the data were collected. The targets for validation were a secure and accurate record of Castor identification records with corresponding medical record numbers; no case/data duplication; and data accuracy is >95%.

Data analysis

Pooled quantitative data were analysed using Microsoft Excel (Version 16.41) to present descriptive statistics. If a data point was missing from a case, the denominator was adjusted to account for that. The data were utilised to create tables summarising demographic characteristics, tumour characteristics, operative characteristics, and methods utilised to reduce COVID-19 transmission. For three centres, data were available prior to "lockdown" commencing (01/11/2019 – 22/03/2020). The Mann Whitney Test was used for comparative analysis of the age of patients and the length of time they stayed in the neurosurgical unit for patients from these three centres included in the above cohort with the data available pre-lockdown from the same centres. The Fisher's exact test was used to analyse the remaining data points from the above cohort with pre-lockdown data for patients from these three centres. Statistical analysis was performed using GraphPad (Prism, Version 5) with statistical significance set at p>0.05.

Results

General

Data were collected on a total of 124 patients across twelve tertiary neurosurgical centres. Neurosurgical centres contributed anywhere from 2 to 21 patients. There were no duplicates in cases/data in the records audited for data validation. All centres fulfilled the >95% accuracy target per case.

Patient characteristics

The median age of patients within the study was 50.5 years (range: 7 – 82). There were 65 male patients and 59 female patients. At presentation, body mass index (BMI) was recorded in 118 patients (n=118/124, 95%). Thirty-two patients (n =32/118, 27%) had a body mass index (BMI) greater than 30 (TSA: 29/96, 30%; EEA: 3/22, 14%). The patient's vision at presentation was recorded in 121 patients (n=121/124, 98%). Visual loss (acuity and/or field deficits) was present in 83 patients (n=83/121, 69%) preoperatively (TSA: 69/99, 70%; EEA: 14/22, 64%). Thirty patients (n=30/124, 24%) presented with anterior pituitary deficiency requiring hydrocortisone preoperatively (TSA: 25/102, 25%; EEA: 5/22, 23%). Five patients (n=5/124, 4%) had posterior pituitary deficiency requiring desmopressin preoperatively (TSA: 4/102, 4%; EEA: 1/22, 5%). Table 1 summaries the information above. Comparing pre- and intra-lockdown preoperative factors at three pilot centres, a larger proportion of patients operated on during the lockdown had visual compromise preoperatively compared to the pre-lockdown cohort (p = <0.01) (Table 2).

The majority of tumours were pituitary adenomas (n=88/124, 71%) – mostly macroadenomas (n=82/88, 93%). There were 63 non-functioning pituitary adenomas (n=63/124, 51%) of which 62 were macroadenomas (n=62/63, 98%). Of the functioning pituitary adenomas (n=25/124, 20%), 20 were macroadenomas (n=20/25, 80%). Of those patients who had functioning pituitary adenomas, 20 had either Cushing's disease or Acromegaly/Gigantism (Cushing's disease:10/25, 40%; Acromegaly/Gigantism: 10/25, 40%). All of the other pathology (n=36/124, 29%) were greater than or equal to 1cm in size. The characteristics of the remaining tumours can be found in Table 3.

COVID-19 Screening Pre-operatively

Pre-operatively, two patients (n=2/124, 2%) presented with symptoms associated with COVID-19: one with a new cough and the other with shortness of breath. Neither of these patients were positive for COVID-19 when screened and both eventually underwent endoscopic surgery that utilised the TSA - one after two weeks self-isolation and negative swab, and the other after CT thorax and swab were negative (without isolation owing to clinical urgency). One-hundred-and-sixteen patients (n=116/124, 94%) underwent COVID-19 testing pre-operatively (TSA: 95/102, 93%; EEA: 21/22, 95%). Seven patients did not undergo COVID-19 testing pre-operatively, most commonly owing to clinical urgency and lack of rapid testing facilities at the time (TSA: 6/102, 6%; EEA: 1/22, 5%). Of those who underwent screening, all patients were screened using a swab (n=116/116, 100%) with one patient

also screened via CT thorax (n=1/116, 1%). One patient (n=1/116, 1%) tested positively via swab for COVID-19 pre-operatively. This patient (52 year old male) was isolated for two weeks pre-operatively, retested pre-operatively and underwent endoscopic TSA for pituitary macroadenomas after negative re-screening via swab. Swab types were examined at initial pilot centres (n=4), and were either ribonucleic acid (RNA) polymerase chain reaction tests (n=2/4) or RNA transcription-mediated amplification tests (n=2/4).

Operation characteristics

The majority of operations (n=47/124, 38%) took place in July (Figure 1). The median caseload during the pandemic was 44.8% (IQR: 39.4% - 49.3%) of usual operative volume - when compared to the caseload in the same period but in the previous year (2019), at selected core pilot centres (n=3).

The majority of cases utilised the TSA (n=102/124, 82%). Of TSA cases, 91 were done endoscopically (n=91/102, 89%) and 11 were done microscopically (n=11/102, 11%). 92 of the cases that utilised TSA were the primary surgery (n=92/102, 90%). The most common pathologies operated on via TSA included: non-functioning pituitary adenomas (n=61), functioning pituitary adenomas (n=24), and craniopharyngiomas (n=4) (Table 3). The EEA was used 22 (n=22/124, 18%) times. The most common pathologies operated on via EEA included: craniopharyngiomas (n=9), meningiomas (n=2), chordomas (n=2) and non-functioning pituitary adenomas (n=2) (Table 3). Twenty of the cases that utilised EEA were the primary surgery (n=20/22, 91%).

Theatre staff involved in the 124 operations wore a range of PPE. The PPE utilised included surgical face masks (TSA: 2/102, 2%; EEA: 0/22, 0%), FFP3 masks (TSA: 82/102, 80%; EEA: 17/22, 77%), powered hood respirators (TSA: 45/102, 44%; EEA: 10/22, 45%), eyeglasses (TSA: 59/102, 58%; EEA: 15/22, 68%), face shields (TSA: 47/102, 46%; EEA: 10/22, 45%), standard surgical gowns (TSA: 59/102, 58%; EEA: 12/22, 55%), double surgical gowns (TSA: 2/102, 2%; EEA: 0/22, 0%), and reinforced surgical gowns (TSA: 26/102, 25%; EEA: 5/22, 23%). Additional measures to reduce the risk of airborne transmission are listed in Table 4.

Postoperative complications and screening

The median length of patient stay was 4 days (range: 0 – 20 days) for the entire group, 3 days (range: 0 – 20 days) for the TSA group and 7.5 days (range: 1 – 20 days) for the EEA group. Overall, 28 patients (n=28/124, 23%) had postoperative complications (TSA: 19/102, 19%; EEA: 9/22, 41%). The most common complications were diabetes insipidus (TSA: 7/102, 7%; EEA: 4/22, 18%), post-operative CSF rhinorrhoea (TSA: 4/102, 4%; EEA: 2/22, 9%), syndrome of inappropriate antidiuretic hormone secretion (TSA: 4/102, 4%; EEA: 1/22, 5%). Other complications involving cases that used TSA included residual disease (n=1/102, 1%), meningitis (n=1/102, 1%), sellar abscess (n=1/102, 1%), unspecified hyponatraemia (n=1/102, 1%), and mono-ocular blindness (n=1/102, 1%). Among cases that used EEA, other complications included residual disease (n=2/22, 9%), and unspecified hyponatraemia (n=1/22, 5%). There were no deaths within 30 days of operation among the 124

patients. In the one patient with a recent history of COVID-19 infection, they had transient diabetes insipidus post-op and no concerns for post-op COVID-19 infections or respiratory compromise. There were no significant differences in postoperative outcomes when comparing pre- and intra-"lockdown" postoperative outcomes at three pilot centres (Table 2).

Of the 124 patients, COVID-19 data at 30 days post-operatively was available from 114 patients (n=114/124, 92%). Post-operatively, one patient (n=1/124, 1%) presented with symptoms associated with COVID-19: a new cough. This patient was not positive for COVID-19 when screened. Nineteen patients (n=19/124, 15%) underwent COVID-19 screening within 30 days post-operatively (TSA: 11/102, 11%; EEA: 8/22, 36%). They were all screened using a swab, and no patient tested positive for COVID-19. Data on staff involved in surgery were available for 48 cases only. None of the staff tested positive for COVID-19 within 30 days post-operatively.

Discussion

Principal findings

To our knowledge, this is the first multicentre study reporting data of contemporaneous endonasal skull base operative practice during the COVID-19 pandemic.

As expected, operative caseload was lowest at the peak of the pandemic (March) and increased over time as operative protocols were established and infection rates reduced. The majority of these endonasal neurosurgical cases were pituitary adenomas (n=88/124, 71%), and the majority of patients were symptomatic preoperatively: visual loss 83 patients (n=83/121, 69%), anterior pituitary deficiency requiring hydrocortisone (n=30/124, 24%), and/or posterior pituitary deficiency requiring desmopressin (n=5/124, 4%). The most common approach used was the TSA (n=102/124, 82%). Theatre staff involved in these operations adhered to international guidance [12] by wearing at least level 2 PPE. There was considerable heterogeneity in the PPE worn, but the PPE items worn in the majority of cases were FFP3 masks (n=99/124, 80%), and eyeglasses (n=74/124, 60%). Adaptations to surgical techniques included minimising drilling, draping modifications, and using nasal iodine wash.

At 30 days postoperatively, there was no evidence of COVID infection (no symptoms or no positive result on testing) in our cohort, and no mortality. One patient (n=1/121, 1%) tested positively for COVID-19 pre-operatively and was isolated for two weeks, with negative swab screening before they were operated on. This patient had the post-operative complication of transient diabetes insipidus but no other complications were reported at 30 days postoperatively.

Findings in the context of literature

There are few existing papers that provide data on patients who have undergone pituitary surgery during the COVID-19 pandemic. A case report from Wuhan, China that described a patient developing COVID-19 within the first week post-endoscopic endonasal pituitary surgery, although pre-operative swab screening was not reported so it was unclear whether this was a pre- or postoperative infection [19]. Additionally, a case series from Cambridge, UK reported that none of 9 consecutive patients undergoing pituitary surgery or skull base surgery between 30th March and 28th April contracted COVID-19 following the adoption of a risk-mitigation protocol [12]. Similar risk-mitigation strategies were subsequently advocated for by the Professional Education Committee of the Pituitary Society. Our international, multi-centre study supports the findings of this latter paper, as we did not find a greater risk to patients of acquiring COVID-19 if they underwent endonasal surgery during the course of this pandemic. Our results also suggest that a standardised, risk-mitigation strategy that takes earlier guidance into account may allow for normalisation of activity. Our results join a growing body of literature that shows that surgery is safe for patients with negative SARS-CoV-2 preoperative tests in a COVID-19 free surgical pathway [24,25]. The preoperative swabs used in our series were RNA polymerase chain reaction (PCR) and transcription-mediated amplification (TMA) via nasopharyngeal

swab. A single swab is estimated to have a sensitivity of 70% and specificity of 95% – with the true predictive value based on factors such as symptoms and disease prevalence[12,26,27]. However, resumption of full elective workloads will depend on wider national and international factors that protect patients from becoming infected with SARS-CoV-2, and therefore avoid delays to their surgery. The non-COVID-19 morbidity of patients with pituitary pathology is an increasing concern, and our results may go some way in allaying concerns about performing surgery during this period.

Limitations

There are several limitations to the study, calling for a tempered assessment of findings. Firstly, owing to the reduced caseloads aimed at mitigating the impact of COVID-19, we have a moderate sample size, particularly with respect to EEA. Owing to the recency of cases and the urgency to inform policymakers about the risks to surgical patients, follow-up was limited to a 30-day postoperative period. In addition, as this is a prospective cohort study, data points were purely observational and across the context of multiple centres. Due to its observational nature, not all patients were screened post-operatively for COVID-19 and we were reliant on these patients self-reporting any COVID-19 symptoms if and when they developed. Similarly, there is a lack of robust and consistent data regarding the symptoms or infection rates of the surgical team. The most significant limitation is the paucity of baseline data to compare against. The pre-pandemic dataset used in this study for limited comparative analysis is non-consecutive and small in size. The main CRANIAL study is still ongoing and should provide the baseline data to correlate our findings here against when it is completed [21].

Conclusions

As operative protocols were established and infection rates reduced, the number of endonasal operation increased. Guidelines published by the Professional Education Committee of the Pituitary Society were adhered to. There were no post-operative COVID-19 infections, and therefore morbidity or mortality, in any of the patients operated on. This suggests that a risk mitigation approach may enable timely pituitary surgery to continue safely during the COVID-19 pandemic.

Ethical approval

Formal institutional ethical board review and informed consent from human participants was not required owing to the nature of the study (seeking to evaluate local services as an observational study) and this was confirmed with the Health Research Authority, UK.

Consent

Not applicable, please see the ethical approval section.

Data availability
Data available upon request

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Figures

Figure 1: Number of operations per month.

Tables

Table 1. Summary of Patient Demographics. TSA = Trans-sphenoidal approach. EEA = expanded endonasal approach.

Table 2. Comparison of baseline data points and postoperative outcomes at 3 centres pre and intra COVID era. Visual loss was a significantly more common presenting complaint among intra-pandemic cases compared to pre-pandemic cases.

Table 3. Number of cases with each type of tumour. TSA = Trans-sphenoidal surgery with a submucosal approach. EEA = expanded endonasal approach.

Table 4. List of additional measures taken by neurosurgical centres to reduce the risk of airborne transmission of COVID-19

Supplementary Information

Supplementary information 1: Author affiliations

Tables

Table 1: Summary of Patient Demographics. TSA = Trans-sphenoidal approach. EEA = expanded endonasal approach.

Approach	TSA	EEA	Total
Total patients	**102**	**22**	**124**
Males	54	11	65
Females	48	11	59
BMI > 30	29	3	32
BMI < 30	68	19	87
Visual Loss	69	14	83
No Visual Loss	30	8	38
Anterior Pituitary Deficiency Requiring Hydrocortisone Preoperatively	25	5	30
Posterior Pituitary Deficiency Requiring Desmopressin Preoperatively	4	1	5

Table 2: Comparison of baseline data points and postoperative outcomes at 3 centres pre and intra COVID era. Visual loss was a significantly more common presenting complaint among intra-pandemic cases compared to pre-pandemic cases. [a] Mann Whitney U test. [b] Fishers Exact test. TSA = Trans-sphenoidal approach. EEA = expanded endonasal approach.

Approach	Number pre-pandemic (% of total)	Number Intra-pandemic (% total)	P-value
Total patients	60	45	
Preoperative variables			
Median age *(range)*	52.7 (18–84)	45 (8-82)	0.08 [a]
Visual loss	21 (35%)	32 (71%)	<0.01 [b]
Anterior Pituitary Deficiency (requiring hydrocortisone)	12 (20%)	12 (27%)	0.49 [b]
Posterior Pituitary Deficiency (requiring desmopressin)	1 (2%)	2 (4%)	0.58 [b]
Tumour size >1cm in diameter	49 (82%)	41 (91%)	0.26 [b]
Operative time			
Median operation time in minutes (*range*)	83 (35-200)	80 (35-302)	0.28 [a]
Median operation time for TSA in minutes (*range*)	80 (35–195)	76 (35-230)	0.78 [a]
Median operation time for EEA in minutes (*range*)	151 (83–200)	259 (137-302)	0.21 [a]
Postoperative variables			
Median length of stay in days	4 (1-20)	5 (1-20)	0.18 [a]
General complications	10 (17%)	15 (33%)	0.06 [b]
CSF rhinorrhoea (biochemically confirmed or requiring operation)	3 (5%)	4 (9%)	0.46 [b]
CSF rhinorrhoea requiring operation (CSF diversion or direct repair)	2 (3%)	3 (7%)	0.65 [b]

Table 3: Number of cases with each type of tumour. TSA = Trans-sphenoidal surgery with a submucosal approach. EEA = expanded endonasal approach.

Type of tumour	TSA	EEA	Total
Non-functioning pituitary adenomas	61	2	63
Functioning pituitary adenomas	24	1	25
Craniopharyngiomas	4	9	13
Apoplexies	2	1	3
Rathke's cleft cysts	3	0	3
Chordomas	0	2	2
Cystic lesions (unspecified)	0	2	2
Meningiomas	0	2	2
Arachnoid cysts	1	0	1
Germinomas	1	0	1
Hypophysitis	1	0	1
Melanoma metastasis	1	0	1
Meningoencephalocele	0	1	1
Mucinous glands	1	0	1
Prostate metastasis	1	0	1
Sinonasal carcinoma	0	1	1
Sinonasal endocrine tumour	1	0	1
Squamous cell carcinoma	0	1	1
Undefined neuroendocrine tumour	1	0	1

Table 4: List of additional measures taken by neurosurgical centres to reduce the risk of airborne transmission of COVID-19

Additional Measures Taken to Reduce the Risk of Airborne Transmission	
Pre-operative modifications	Patients isolated 2 weeks preoperatively
	Reduction in the number of staff in the theatre room
	Most theatre staff restricted from entering theatre until 10 minutes after intubation
Intra-operative modifications	Patient covered with clear plastic cover over regular drape
	Instruments sealed with tape and plastic drapes
	Apron use under gowns
	Use of 9 ml of 0·5% povidone-iodine (PVP-I) solution for skin and mucous membranes as mouth wash
	Instillation of 0.3 ml of 0·5% PVP-I solution for skin and mucous membranes in each nostril
	Change from fluoroscopy to Stealth to decrease movement of equipment through multiple theatres
	Minimisation of bone drilling
Post-operative modifications	Nasal packing avoided where possible
	Most theatre staff were not present during extubating

Figures

Figure 1: Number of operations per month with overlay of number of COVID-19 cases in the UK during the study period (data extracted from Public Health England database). There were no cases reported from March 23rd to March 31st.
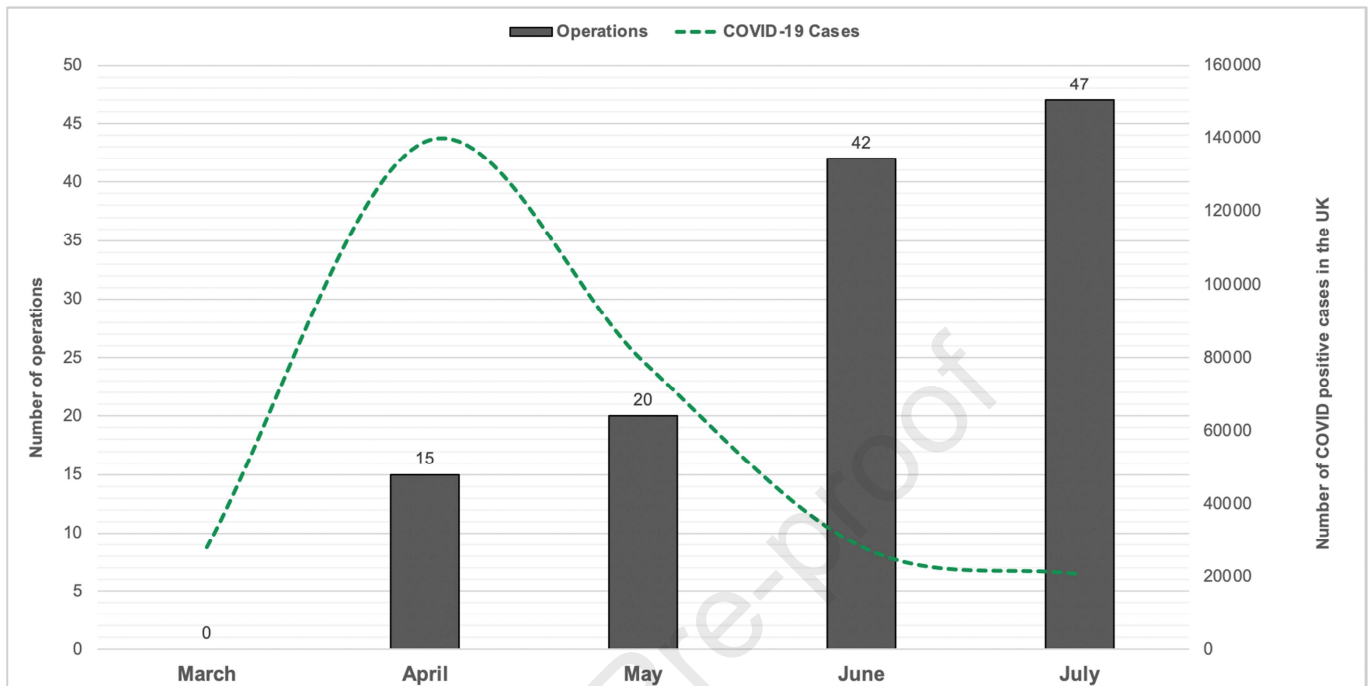
CSF rhinorrhoea after endonasal intervention to the skull base (CRANIAL).

Part 2: Impact of COVID-19

Abbreviations

CRANIAL: CSF Rhinorrhoea After Endonasal Intervention to the Skull Base

CSF: Cerebrospinal fluid

TSA: Transsphenoidal approach

EEA: Expanded endoscopic endonasal approach

CI: Confidence interval

Declaration of interests

☒ The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

☐The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: