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REVIEW ARTICLE

The impact of the COVID-19 pandemic on the delivery of lower limb arthroplasty: A literature review

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Abstract

Hip and knee arthroplasty is an extremely successful and cost-effective procedure that is widely performed to restore function and alleviate pain. The arrival of the SARS-CoV-2 virus (COVID-19) brought significant disruptions to delivery of surgery worldwide, including lower limb arthroplasty. Three years on from the start of the pandemic the effects of the virus are still present. This literature review aims to explore current data published from our single specialty orthopaedic centre and data collected nationally and internationally, on the impact of the COVID-19 pandemic on lower limb arthroplasty.

Elective hip and knee arthroplasty in the UK fell by approximately 40% and 50% respectively (2020 vs 2019) and by the end of 2021 the number of procedures completed still remained below pre-pandemic levels. As a result, elective waiting times are longer than ever before, with more patients suffering worse health states and a significant impact on quality of life. The UK National Hip Fracture Database showed an active COVID-19 infection was associated with a three-fold greater risk of 30-day mortality post lower limb arthroplasty. Several reports have also correlated peri-operative COVID-19 infection with increased risk of systemic complications with the virus such as pneumonia, deep vein thrombosis, pulmonary embolisms, acute kidney injury and myocardial infarction to name a few.

NHS England provided guidelines for safe recommencement for elective operating. Upon adoption of these recommendations, several orthopaedic units found similar rates of post-operative complications and mortality to pre-pandemic levels, demonstrating that safe elective care can be delivered even during an emergency pandemic setting. The development of rapid testing, use of personal protective equipment and introduction of pre- and post-operative isolation protocols were effective measures to allow elective surgery to restart. For infected individuals awaiting surgery, delays of at least seven weeks are recommended to reduce complication rates. There is limited literature discussing the impact of the vaccine on post-operative complications and mortality. Early reports however have suggested vaccinated individuals benefit from a reduced mortality risk in emergency cases of hip fracture surgery, but this is an area which would benefit from further research.

Introduction

Lower limb arthroplasty (total hip replacement (THR) and total knee replacement (TKR)) are some of the most cost-effective and successful surgical operations and have been proven to significantly improve quality of life[1,2]. The arrival of the SARS-CoV-2 (COVID-19) virus brought severe disruptions to hospitals, and in particular, delivery of elective healthcare worldwide[3-8]. Significant restructuring and reallocation of resources was required to cope with the pressures faced[9,10]. To date, there have been over 6.7 million deaths from COVID-19 worldwide[11]. Almost three years on from the start of this pandemic, several reports have been published discussing the challenges posed and measures implemented to cope. Our single-speciality institution, in the United Kingdom published data on the morbidity and mortality of patients undergoing lower limb arthroplasty surgery during the initial surge of the COVID-19 pandemic[12]. Interestingly, despite early reports from COVIDSurg collaborative group of increased 30-day all-cause mortality (23.8%) and pulmonary complication rates (51.2%)[13], our hospital's initial reports did not observe such a spike in mortality. In this regard our orthopaedic centre noted only one post-operative mortality out of the six patients which were infected with COVID-19 during the study period. Our hospital utilised guidance from various specialist societies and NHS England to create a "managed pathway" to minimise exposure to the patient, however it should be noted where patients did contract the virus, mortality was high (16.7%)[12].

Larger scale reports have since been released by The British Journal of Anaesthetics, including a retrospective study of 2,666,978 patients undergoing all types of surgery between January 2020 - February 2021 (of which 28,777 patients, or 1.1%, had associated COVID-19 infection). This study demonstrated patients undergoing surgery with COVID-19 infection had a significantly higher risk of 90-day-mortality (21.4% vs 0.8%, Odds Ratio (OR) 5.7, $p<0.001$). Analysing the data further, sub-dividing the elective and emergency surgery the 90-day-mortality odds ratios associated with COVID-19 infection was 25.8 (7.1% vs 0.1%; $P<0.001$) and 5.5 (25.1% vs 3.4%; $P<0.001$) respectively[14].

The objective of this literature review is to explore the impact of COVID-19 on delivery of lower limb arthroplasty. Our paper aims to assist hospitals in effectively planning for unforeseen circumstances (such as a pandemic), including how to continue to deliver high-quality elective care. This literature review will also discuss how to tackle the backlog of cases as safely as possible moving forward.

Changes in Practice and Hospital Reconfiguration

Sufferers of COVID-19 display a spectrum of disease presentations, from asymptomatic to severe respiratory distress. During the initial surge, several factors were believed to have contributed towards the rapid spread of COVID-19; a high transmission rate, coupled with a 5-14 day incubation period, meant that a large proportion of asymptomatic individuals were able to continue with their

daily activities and unknowingly infect other more vulnerable individuals[15].

Transmission rates (R value) were reported as high as 1.9 in parts of the UK at the peak times of the pandemic[16]. This meant on average, one infected case would infect 1.9 other people. With an R valve >1 this led to an exponential rise in cases and hospitals were required to quickly adapt. Once rapid COVID testing became ubiquitous amongst NHS facilities, all patients were screened on admission and pre-operatively. Public health interventions and non-pharmaceutical measurements were effective in reducing the transmission of COVID-19[17]. Measures implemented included social distancing, travel restrictions, isolation protocols, national lockdowns and compulsory utilisation of personal protective equipment (including mask, hoods, gloves and aprons).

UK hospitals underwent significant restructuring during the pandemic. During the initial surge, our hospital, a regional specialist elective orthopaedic centre was utilised to provide emergency orthopaedic care for neck of femur fracture patients but also urgent arthroplasty procedures. Our hospital received patients from four regional trauma network hospitals[9]. Data collected between March 28, 2020, to May 25, 2020, showed 167 hip fracture patients were treated at our newly reconfigured elective site, with 29 patients (17.4%) testing positive for COVID-19 during their admission. Overall 30-day mortality rate was 10.2%; however, for those diagnosed COVID positive, the case-fatality rate was 34.5%[9], which were similar to rates reported within the UK and internationally[18-23]. This data demonstrates that reconfiguration of elective hospital during such unprecedented times is a safe approach to help cope with the increased demands of acute trauma surgery, albeit at the expense of elective operations.

Reduction in Operating Volume

The National Health Service (NHS) and British Orthopaedic Association advised suspending all non-urgent lower limb arthroplasty to redirect resources and help cope with the increased pressures to ensure urgent time critical trauma operating was performed in a timely manner[24,25]. Elective surgery restarted at reduced capacity several months later[5,7,26]. National joint registry data for England, Wales and Northern Ireland outlined that elective primary hip and knee arthroplasty reduced by approximately 40% and 50% respectively in 2020 vs 2019 (2020 UK primary hip arthroplasty cases: 59,911 vs 2019 UK primary hip arthroplasty cases: 99,361; 2020 UK primary knee arthroplasty cases: 56,180 vs 2019 UK primary total knee replacement cases: 107,067)[27,28]. Other international reports from the USA, Poland, Hong Kong and India all showed a similar reduction in the volume of elective hip and knee arthroplasty, with figures ranging between 30-60% fewer[3-8,26,29].

Elective procedures were cancelled due to various reasons, including redeployment of surgical staff to medical, emergency and intensive care; lack of surgical staff due to sickness or isolation; shortages of personal protective equipment, and positive COVID-19 tests during pre-admission testing.

Emergency trauma cases by their very nature were required to continue through the early stages of pandemic, however the National Hip Fracture Data for England, Wales and Northern Ireland (UKNHFD), did report a 6% decrease in operating volume in 2020 as compared with 2019 (63,284 in 2020 vs 67,302 in 2019).

The halting of elective surgery accelerated the growing backlog of elective cases and put even more pressure on hospitals. Some papers have quoted an average increase of two months to wait times [30]. Orthopaedic units had to find creative solutions to utilise already limited resources and improve efficiency to not only return to pre-pandemic levels but exceed it in order to catch up and meet current demands.

The pandemic had a negative impact on the training of trainees. It was multifactorial, reduction in operations performed, redeployment to acute services and leave due to developing COVID-19 symptoms or covering colleagues with the same. The challenges posed by the pandemic has led to a fall in operative cases completed by trainees up to 50%[31,32]. The impact of this on surgical competency has not been formally researched but training extensions has been required for the trainees to make up for lack of experience. This would reduce new available surgical training posts and reduce the availability of potential new surgical consultants available to tackle waiting lists time in future. If this issue were to reoccur during future pandemics, Sheridan et al suggested that reassignment of senior trainees to high-volume institutions may be one approach to mitigate these effects to trainees worst impacted upon[32].

Mortality

Despite the high virus-related mortality, early reports shared conflicting evidence of COVID-19's impact on post-operative mortality rates. Initial reports from our centre on elective lower limb arthroplasty patients found low COVID-19 prevalence in the post-operative period of 2.7% (6/224), and low 30-day mortality rates of 0.45% (1/224). However, in COVID-19 positive patients, case fatality rates were high at 16.7% (1/6)[12]. Similar findings were found by Karayiannis et al, 2020, who also studied 484 patients undergoing any trauma and orthopaedic procedure over a similar time period with overall 30-day mortality at 1.9% and case fatality rate at 14.5%[33].

A separate report from our institute on hip fracture patients, which are recognised to be rather more vulnerable and to have high mortality, demonstrated a significantly higher prevalence in peri-operative COVID-19 cases 17.4% (29/167), with 30-day mortality rates of 10.2% (17/167) and case fatality rates even higher, at 34.5% (10/29)[9]. Similar findings were seen in a Scottish, multi-centre, retrospective study; they also showed significantly lower 30-day survival compared to those with COVID-19 infection (64.5% vs 91.7%, $p < 0.001$)[34].

The 2021 UKNHFD annual report (examining data representing January 2020 - December 2020) collated the results of 63,284 people from 173 hospitals. All patients were operated

on an emergency basis. 3,730 patients were recorded to have COVID-19 either at the time of their presentation or during admission. Overall 30-day mortality rose to 8.3% in 2020 vs 6.5% in 2019; however, it should be noted that mortality was three times higher in COVID-19 positive patients than those without the infection[18,35]. Mortality rates have not been included in the 2022 NHFD report (representing data collected between January 2021-December 2021) and therefore cannot be commented upon in this review.

Interestingly, systematic reviews and meta-analyses performed by Tripathy et al, 2021[36] & Lim et al, 2022[37] both found no significant differences in 30-day mortality between the pandemic and pre-pandemic data. Lim et al, 2022 combined five studies published up to 28 March 2022 and released the more recent meta-analysis of the two, which directly compared mortality rates after hip and knee joint arthroplasty pre- and during the COVID-19 pandemic, including the earlier of the two studies from the ROH - Agrawal et al, 2021 [12]. All studies included both elective and emergency operations. A total of 3044 patients undergoing hip fracture surgery were included (838 during the pandemic period and 2206 pre-pandemic). However, there were several limitations to this meta-analysis. Data in all studies were taken from early studies, and therefore, in three of the five studies COVID-19 testing was not performed on all patients as a screening protocol. Additionally, a significant proportion of surgeries performed were emergency operations. This was due to the halt on elective operations and so the findings may not be entirely applicable to elective surgery. Furthermore, only a small sample size of confirmed COVID-19 cases was described (12 / 838). Of these twelve cases, there were seven deaths. While these meta-analyses appear to show that continuing elective arthroplasty during COVID-19 was relatively safe, it is difficult to draw on conclusions given the study's limitations. However, the results regarding case fatality do corroborate other study findings: in COVID positive patients, 30-day mortality was high (58.3%).

Gordon et al, 2022 performed a large scale, retrospective, multicentre study in US hospitals, comparing data between 72,002 patients in 2019 and 49,413 patients in 2020 that had an elective total knee arthroplasty (TKA) [3]. No significant difference was found in 30-day mortality (0.08% vs 0.07%; P = 0.858), total complication rates (4.84% vs 4.75%; P = 0.430), revision surgery (1.0% vs 1.0%; P = 0.940), and readmission rates (2.8% vs 2.6%; P = 0.053).

It is important to note that studies which compared data from pre-COVID and COVID cohorts showed a significant difference in the proportion of elective and emergency operations performed. As aforementioned, national and specialist guidelines advised halting of all elective surgery in the early months of the pandemic. Therefore, the vast majority of cases performed during the "pandemic period" of these studies (particularly between months of March to May) were emergency operations in which patients tended to be more co-morbid and usually had higher risk of mortality which may potentially confound the results.

COVID-19 testing was not performed on all patients on arrival or preoperatively, and therefore the prevalence of COVID-19 may be underrepresented in these cohorts. It was only after 26th April 2020, almost two months after the first case of COVID-19 was detected in the UK, that all patients were swabbed for COVID-19 on arrival at our centre[9]. Other centres nationwide would have followed similar practice due to an initial lack of rapid testing facilities. Prior to this date, only symptomatic patients were tested for COVID-19 and lack of routine testing likely would have missed asymptomatic patients. Research has shown that a large proportion of COVID-19 infections were asymptomatic[15]. Therefore, the non-COVID status assigned to patients prior may represent false negatives affecting data accuracy.

Peri-operative Complications of COVID-19

Although COVID-19 symptoms are felt to largely affect the respiratory system, there are significant systemic effects too. Several studies have now shown how COVID-19 affects multiple organ systems, with both acute and long-term complications [38-41]. Infected individuals undergoing surgery may exacerbate complications owing to the vulnerable state surgery induces post-operatively[42]. Patients infected with COVID-19 who underwent lower limb arthroplasty have shown a two-to-five-fold increase in complication rates[26,38,43-46].

Forlenza et al, 2022 demonstrated increased risk of systemic complications in patients with a post-operative diagnosis of COVID-19 who underwent a THR or TKR[38]. Multivariate analysis of COVID-19 positive patients found a significantly increased risk of deep vein thrombosis (DVT) (odds ratio (OR) 4.86; P < .001), pulmonary embolism (PE) (OR 6.27; P < .001), acute kidney injury (OR 4.03; P<0.001), cardiac arrest (OR 10.71; P=0.003), pneumonia (OR 25.38; P<0.001), urinary tract infection (OR 1.99; P<0.001), and all complications (OR 3.36; P<0.001). The incidence of DVTs and PEs increased relative to the time between the COVID-19 diagnosis and surgery (10.24 times at 1 month, 7.87 times at 2 months, and 1.42 times at 3 months; P <0.001)[38].

Complications risk was also significantly increased in patients with a pre-operative diagnosis of COVID-19 undergoing neck of femur fracture surgery. Another large US study used an insurance claims database to include 42,002 geriatric patients undergoing hip fracture surgery between 1st April 2020 to 1st December 2020. A total of 678 (1.61%) had a confirmed diagnosis of COVID-19 within 14 days prior to their operation[45]. There was no significant difference in age, sex, or procedure type between the COVID-19 positive and negative patients; however, infected patients did present with more comorbidities than their uninfected counterparts. COVID-19 positive patients were significantly more likely to present with asthma, chronic kidney disease, congestive heart failure, chronic obstructive pulmonary disease, coronary artery disease, diabetes, hypertension and obesity (P<0.05 for all). To adjust for the imbalance of comorbidities, the authors of this study performed case control analysis, matching patients in a 10:1 ratio.

Matched COVID-19 positive patients were still significantly more likely to experience complications within 30-days of their operation (overall complications OR=1.62, P<0.001, Serious adverse events OR = 1.66; P<0.001, Minor adverse events OR = 1.59; P<0.001). Specific models were performed on VTE and pneumonia due to their extensive research in the literature and were found have increased odds ratios of 2.06 and 2.31 respectively (P<0.001).

It appears that COVID-19 is an independent risk factor for post-operative lower limb arthroplasty complications. Both a pre- and post-operative diagnosis have been shown to increase the risk of systemic complications. In addition, a clear correlation is noted between shorter time interval between operation date and infection, for the development of DVT and PE. Lower limb arthroplasty is already a procedure which carries a significant risk of deep vein thrombosis, and COVID-19 infection only increases this chance further. While it is standard practice for all patients to be commenced on prophylactic anticoagulation post-operatively, it is yet to be elucidated whether this dose should be increased in COVID-19 positive patients.

Surgical Delays and Restarting Elective Orthopaedic Work

Both surgery and infection are individual risk factors which increase rates of complications and mortality; combined, this risk rises considerably. It is therefore advised to delay surgery until the patient is deemed safe to proceed. The COVIDSurg collaborative group conducted an international multicentre study, collecting data on 140,231 patients undergoing any type of surgery in the month of October 2020[44] with the aim to determine the optimal time to delay surgery in patients who contracted COVID-19. They used 30-day mortality as the primary outcome and found surgery performed within six weeks of a positive COVID-19 test was associated with an increased risk of mortality (OR: 0-2 weeks delay = 4.1, 3-4 weeks delay = 3.9, 5-6 weeks delay = 3.6; P<0.001). They advised that surgery should be ideally delayed by at least seven weeks, as from this point onwards there was no significant increase in 30-day mortality compared with surgery performed on COVID-19 negative patients (OR 1.40; P=0.107). They also advised that where patients were still symptomatic at the seven weeks, to consider further delays to surgery date. While these findings are not specific to lower limb arthroplasty, the study size and the heterogeneous demographics of these patients (such as sex, country of origin, type of operation, past medical history) will allow for some extrapolation of these findings to our cohort group.

It is well known that delay in trauma surgery is associated with increased complications rates; Holzapfel et al, 2022 showed that the same may be true with elective surgery[47]. They performed a retrospective analysis, identifying 2,480 delayed total joint replacements (TJR) between 2011 and 2020, with an average delay of 13.5±29.6 days. Through multivariable logistic regression analyses, postponed arthroplasty was shown to be an independent risk factor when compared with arthroplasty performed on-time with end outcomes of

higher 90-day revision rate (7.1% vs 4.5%; P<0.001), surgical complications (3.2% vs 1.9%; P<0.001), internal complications (1.8% vs 1.2%; P=0.041) and transfusion rate (2.6% vs 1.8%, P=0.023).

Another study also found that prolonged waiting for hip and knee surgery led to increased length of stays (0.49 days; p < 0.001) [30]. It is possible that longer waiting times contributed to worsening of patient's arthritis and musculoskeletal deconditioning, which in turn would require more post-operative rehabilitation and physiotherapy input increasing their length of stay.

It is also important to remember the impact of delaying surgery to the patient. Clement et al, 2021 analysed 843 EuroQol five dimension (EQ5D) scores from patients awaiting an elective THR or TKR between August and September 2020 [48]. EQ5D scores are a standardised measure of health state: in this study, a score less than zero was considered to be a health state "worse than death" (WTD). During the pandemic, the number of WTD patients doubled when compared to their control cohort questioned in 2014-2017. Each additional month waiting for a TJR was associated with a further drop in EQ5D score (by -0.0135; P = 0.004).

While surgical delays in certain scenarios may be inevitable, it does not come without risks and negative impacts on the patient. Every effort should be made to explore avenues to reduce wait time and tackle the backlog in a safe manner.

When it comes to restarting elective orthopaedic work to tackle the backlog, one centre in Scotland implemented a non-covid "blue stream pathway" devised from guidelines provided by the National Institute of Health and Care Excellence (NICE) for managing planned care episodes [49]. This pathway involves isolation before and after surgery, COVID-19 testing pre-admission, and separation of ward and theatre pathways for "blue" patients. Of the 340 electively operated patients (July 2020 to January 2021), only one patient tested positive during admission (0.29%), mortality rate was 0% and the observed post-operative complications were similar to that of pre-pandemic levels.

Strict compliance to the new UK national protocols at reducing COVID-19 infection for elective surgery meant some centres found lower complications, readmissions, and mortality rates after the resumption of elective surgery in 2020 compared with 2019 [50]. Asopa et al, 2022 reviewed 2,316 consecutive patients undergoing elective orthopaedic surgery between June to December 2020 vs 2019. Of these procedures hip and knee procedures made up over 75% of the workload. Only one case COVID-19 was confirmed post-operatively with no deaths and significantly fewer complications (p<0.05). This paper shows that elective surgery can be safely resumed during a pandemic should resources allow for this.

The USA and Canada use a model of outpatient centres where it is becoming more common to perform elective hip and knee surgery as a day case procedure. This is a safe and cost-effective approach for selected patients. One centre in Canada increased the number of same day discharges, in order to

maintain the number of elective cases completed. Twice as many patients were discharged same day during the 2020 study period compared with 2019, yet were able to demonstrated lower superficial wound infections and no significant change in readmission [51]. Where outpatient models for lower limb arthroplasty exist, increasing the number of same day discharges could be a safe method to improve efficiency to tackle the backlog.

Vaccine

Few studies have been published with regards to the impact of the vaccine in the context of lower limb arthroplasty. Recent evidence has emerged from the Coronavirus Infection in Hip Fractures (CHIP) collaborative group showing the beneficial effect of the vaccines in hip fracture patients [52]. Their observational study across 19 NHS England trusts picked up 337 COVID-19 positive patients and was able to demonstrate a significant decrease in 30-day mortality for vaccinated vs unvaccinated individuals who contracted COVID-19 (5.5% vs 21.7%). The 30-day mortality rate in vaccinated individuals was comparable with their pre-pandemic 2019 controls (7.7% vs 5.0%; P=0.068). While the vaccine does not completely prevent individuals from contracting the virus, it has shown to be protective from a mortality standpoint for those undergoing emergency hip fracture surgery.

Conclusion

During peak times of COVID-19 pandemic, restructuring of the National Health Service was necessary to ensure the timely care of emergency trauma cases. Transformation of elective orthopaedic hospitals proved successfully to help cope with the lack of resources and staff shortages at other units in the trauma network. The halting of elective surgery, whilst necessary at the time, has led to an increased surgical backlog, leaving more patients than ever suffering a poor quality of life, which only worsens for every month their surgery is delayed. Every effort should be made to improve efficiency of orthopaedic units to rapidly assess the backlog. However, in those who have contracted COVID-19, delays of at least seven weeks from their original planned operation date may be necessary on medical grounds as surgery sooner than this has been correlated with increased complication and mortality rates. Both pre-operative and post-operative complications include pneumonia and acute respiratory distress syndrome but also extend beyond the respiratory system to include other organ systems including the cardiovascular and renal systems. The rapid development of point of care testing and managed pathways have shown to be effective in reducing the risk of contracting COVID-19. Vaccination may not eliminate the risk of contracting COVID-19 but has appeared to have a beneficial impact on mortality rates in those undergoing emergency hip fracture surgery. Further studies would be beneficial to assess the impact of vaccination on elective patients and compare the incidence and severity of post-operative complications.

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