

# Personal protection equipment for orthopaedic and trauma surgery during the COVID-19 pandemic: The results of an EFORT survey initiative

Theofilos Karachalios<sup>1,2</sup>, Katre Maasalu<sup>3,4</sup> and Li Felländer-Tsai<sup>5,6</sup>

<sup>1</sup>Orthopaedic Department, University General Hospital of Larissa, Biopolis, Mezourlo Region, Larissa, Hellenic Republic

<sup>2</sup>School of Health Sciences, Faculty of Medicine, University of Thessaly, Biopolis, Mezourlo Region, Larissa, Hellenic Republic

<sup>3</sup>Clinic of Traumatology and Orthopedics, Tartu University Hospital, Tartu, Estonia

<sup>4</sup>Department of Traumatology and Orthopedics, Institute of Clinical Medicine, University of Tartu, Tartu, Estonia

<sup>5</sup>Division of Orthopaedics and Biotechnology, CLINTEC, Karolinska Institutet, Stockholm, Sweden

<sup>6</sup>Trauma, Emergency Surgery and Orthopaedics, Reconstructive Orthopaedics, Karolinska University Hospital, Stockholm, Sweden

Correspondence should be addressed to L. Felländer-Tsai  
**Email**  
li.tsai@ki.se

- Orthopaedic and trauma surgeons performing surgery in the COVID-19 pandemic environment faced problems with availability, use, rationing, modification, compliance and recycling of personal protection equipment (PPE).
- Orthopaedic and trauma surgeons were not well informed concerning the use of PPE for aerosol-generating orthopaedic and trauma procedures.
- Scientific bodies, health authorities and management have provided insufficient guidelines for the use of PPE in aerosol-generating orthopaedic and trauma procedures.
- The availability of specific PPE for orthopaedic and trauma operating theatres is low.
- Hospital management and surgeons failed to address the quality of operating theatre ventilation or to conform to recommendations and guidelines.
- Operating theatre PPE negatively affected surgical performance by means of impaired vision, impaired communication, discomfort and fatigue.
- Existing PPE is not adequately designed for orthopaedic and trauma surgery, and therefore, novel or modified and improved devices are needed.

## Keywords

- ▶ PPE
- ▶ COVID-19

EFORT Open Reviews  
(2022) 7, 122–128

An unknown viral infection causing severe pneumonia erupted in December 2019 in the city of Wuhan, Hubei Province, China, and in January 2020, a novel coronavirus named SARS-CoV-2 was identified as the causative virus (1). In March 2020, the World Health Organization (WHO) declared a global pandemic which dramatically changed the priorities and activities of public and health systems (2). For a considerable period of time, elective surgery was halted and only emergency procedures were carried out depending on country-specific issues (3, 4, 5). The rapid global spread of the virus and the lack of specific treatments led to an increased rate of infections among the general public and health care workers (HCW), and measures of social distancing for the public and the use of personal protection equipment (PPE) for both the public and HCW were enforced. Various recommendations for the use of PPE, based on poor evidence, appeared

in the literature for general and orthopaedic surgeons (5, 6, 7, 8, 9).

Soon, various problems with a substantial impact on the working environment and staff safety appeared related to the availability, use, rationing, modification, compliance and recycling of PPE (7, 10, 11, 12). Later, it was also observed that PPE might cause problems to surgeons of certain specialties and adversely affect their surgical performance, for example, due to a negative impact on vision and communication (13, 14, 15, 16, 17). Moreover, evidence-based literature has not given detailed comparative recommendations for the use of different kinds of PPE in the operating theatre and even the WHO has failed to address this issue in the operating theatre environment (18).

For orthopaedic and trauma surgeons, the control of disease transmission on the wards and in the operating theatre is of paramount importance since the majority of

orthopaedic and trauma emergency and elective surgeries are aerosol-generating procedures (5, 8, 9, 19, 20, 21).

We report the results of a survey among European orthopaedic and trauma surgeons, under the auspices of the European Federation of Orthopaedics and Traumatology (EFORT), which assesses the perception, availability, usage, modification, compliance and efficacy of the different types of PPE used in orthopaedic wards and theatres.

## Material and methods

In March 2021, EFORT started a PPE initiative for orthopaedic and trauma surgeons and the industry. At an initial stage, due to a lack of reliable data, a questionnaire was developed in order to attract relevant data. The study design was a prospective online survey sent to orthopaedic and trauma surgeons (expert opinion) practising both Orthopaedics and Traumatology. All participants' names were in the EFORT mailing database. The survey was also sent to members of the European Hip Society, members of the European Knee Associates and members of other European National Orthopaedic Societies as well as made available on EFORT website and newsletters. Approval from an institutional review board was received from two different countries (Sweden Ref no 2020-06288 and Greece Ref no 20/11/2020-02585) despite the fact that no patient data or personal records were involved. All respondents were anonymous.

The survey was created with surveymonkey (<http://www.surveymonkey.com>, San Mateo, CA, USA), an online data collection programme. The survey included 24 questions selected by the EFORT board. It collected demographic data (working position, level of experience and country of clinical practice), orthopaedic ward and operating theatre PPE usage data, PPE availability and training data, and the surgeon's subjective impressions regarding PPE efficacy, safety and the likelihood of adverse reactions during surgery. A link to the survey was then sent out on the 1st of December 2020, and the survey was finally closed on the 25th of May 2021. The questions were formulated so that respondents could choose only one reply. Frequencies and percentages were calculated for the collected data.

## Results

### Demographics

The survey was fully completed by 695 respondents. The country of practice for 684 respondents (98.4%) was Europe and for 11 (1.6%), it was outside Europe. Four hundred and seventy-one respondents (67.77%) were experienced, with more than 10 years of clinical practice, and 224 (32.23%) had less than 10 years of clinical practice as specialists. Of the 695 respondents, 224 (32.23%) were practising orthopaedics and/or traumatology in an

academic/university hospital, 305 (43.88%) in a state/community hospital and 138 (19.86%) in a private hospital and/or office.

### Virus contact

Five hundred and eighty-three (83.88%) respondents had come into contact with COVID-19-positive patients (either symptomatic or asymptomatic) in their professional practice, 67 (9.64%) had not and the remaining 45 (6.47%) were uncertain. Three hundred and fifty-three (50.79%) respondents had operated on a COVID-19 patient, 284 (40.86%) had not, while a further 58 (8.35%) were unsure. Five hundred and seventy-nine (83.31%) respondents stated that they had had at least one colleague or staff member who developed symptoms or had a PCR-positive test, 108 (15.54%) had not and 8 (1.15%) were uncertain.

### Information

Five hundred and seventy (82.1%) respondents considered themselves well informed regarding PPE for operating theatre surgeons in general, 61 (8.78%) did not and 64 (9.21%) were unsure. At the same time, 566 (81.44%) considered themselves well informed regarding PPE for HCW in general, 68 (9.78%) did not and 61 (8.78%) were unsure. Finally, 355 (51.08%) considered themselves well informed regarding PPE for aerosol-generating (both orthopaedic and trauma) procedures, 206 (29.64%) did not and 134 (19.28%) were unsure.

### Hospital directives

Four hundred and seventy-six (68.49%) respondents were aware of the introduction of relevant guidelines for the use of PPE on the wards, in the clinics or operating theatres of their hospital, 133 (19.14%) were not and 86 (12.37%) were uncertain. In contrast, only 271 (38.99%) respondents were aware of the introduction of guidelines for the use of PPE for aerosol-generating procedures (power tools, pulsatile lavage, electrocautery and radiofrequency) when operating on COVID-19 PCR-positive patients in their hospital, 294 (42.30%) were not and 130 (18.71%) were unsure. Five hundred and sixty-two (80.86%) respondents confirmed that their hospitals had separate management pathways for COVID-19 and non-COVID-19 patients, 111 (15.97%) did not and 22 (3.17%) were unsure.

### COVID-19 testing

Five hundred and seventy-two (82.30%) respondents confirmed that their hospital routinely use PCR testing for COVID-19 patients, 104 (14.96%) did not and 19 (2.73%)

were unsure. At the same time, 330 (47.48%) confirmed that their hospital routinely use antigen testing for COVID-19 patients prior to surgery, 318 (45.76%) did not and 47 (6.76%) were uncertain.

*Education*

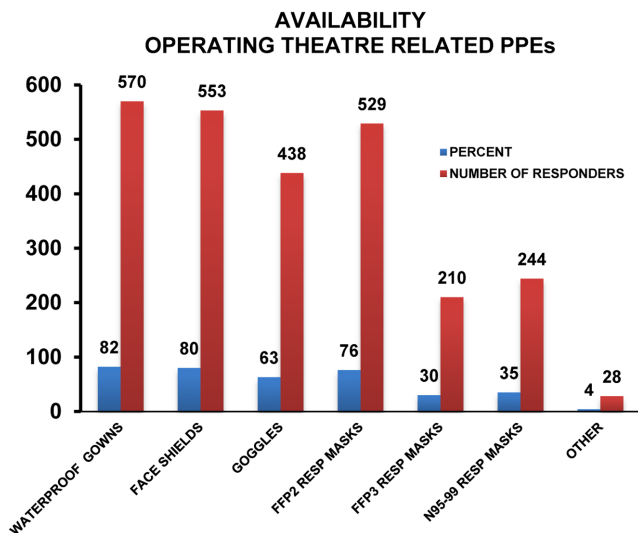
Three hundred and forty-seven (49.92%) of the respondents confirmed that they had been instructed about the systematic or specific use of PPE, 192 (27.63%) had not and 156 (22.45%) were unsure.

*Availability*

Five hundred eighty-nine (84.75%) respondents confirmed that sufficient amounts of masks, face shields, goggles and gloves were available in the wards and clinics of their hospitals, 77 (11.08%) said there were not and 29 (4.17%) were uncertain. Three hundred and sixty-three (52.23%) respondents confirmed that there have been temporary PPE shortages in their hospitals, 238 (34.24%) did not and 94 (13.53%) were uncertain. Operating theatre availability of PPE in sufficient amounts is shown in Fig. 1.

*Operating theatre environment*

Six hundred and four (86.91%) respondents confirmed that routine surface decontamination is performed on the wards, in the clinics and operating theatres of their hospitals, 45 (6.47%) did not and 46 (6.62%) were uncertain. Two hundred and ninety-seven (42.73%) respondents confirmed that the ventilation system in their operating theatres had been checked or improved in order to meet contemporary specifications, 152 (21.87%) said



**Figure 1** Availability (percentage and number of responders) of different operating theatre PPE is shown.

it had not and 246 (35.40%) were uncertain. Surgeons' perceptions of PPE efficacy, safety and possible existence of adverse reactions during surgery are shown in Fig. 2. PPE was reported to impair vision in 402 respondents (58%). The corresponding figure was 331 (48%) for impaired communication. Surgical fatigue was reported in 183 (26%) respondents and discomfort in 470 (68%). Impaired surgical performance was reported by 185 (27%).

*Compliance*

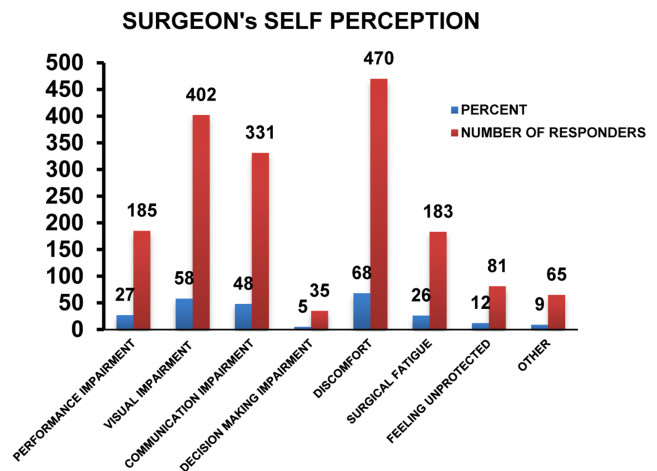
In the case of availability of PPE in the private office or hospital, along with regulations for its use, the level of compliance by staff and surgeons with these regulations is shown in Figs 3 and 4.

*Modified PPEs*

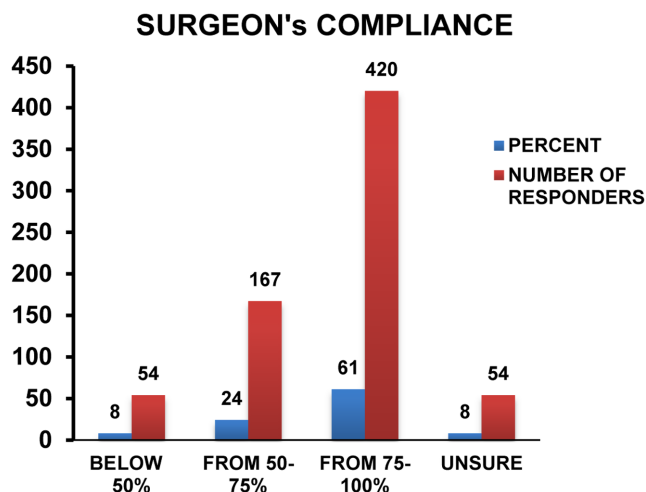
One hundred and four (14.96%) respondents confirmed that they had modified PPE in their hospitals, 356 (51.22%) had not and 235 (33.81%) were unsure.

**Discussion**

The COVID-19 pandemic has caused dramatic changes in every step on the patient pathway, from pre-hospital emergency diagnosis and treatment, emergency orthopaedic surgery, anaesthesia and post-operative management (8). The impact on the working environment and staff safety has been considerable. A year and a half following the initial pandemic shock, containment measures such as lockdowns and quarantines were gradually removed and the medical community has started to reorganise medical services at various levels

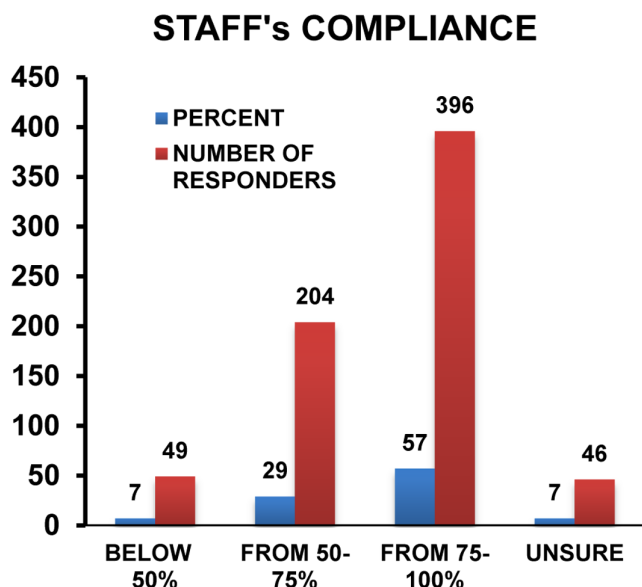


**Figure 2** Surgeons' perception (percentage and number of responders) of side effects caused by intra-operative usage of PPE is shown.



**Figure 3** Surgeons' compliance (percentage and number of responders) with the use of PPE in the private office or hospital settings is shown.

keeping in mind the possibility of future waves of the pandemic, perhaps caused by variants of COVID-19. Orthopaedic surgery has been progressively reestablished at various rates depending on country-specific issues (3, 4). Orthopaedic surgery involves several aerosol procedures with the use of high-speed saws, power drills, pulsed lavage, suction and the use of electrocautery (5, 8, 9, 19, 20, 21). Initially, the possibility of shedding of blood and wound droplets was overcome with the extensive use of general PPE such as masks, protective eyewear,



**Figure 4** Staff compliance (percentage and number of responders) with the use of PPE in the private office or hospital settings is shown.

goggles and visors. Various other types of PPE were later used in order to avoid virus transmission on the wards and in the operating theatre (5, 6, 7, 8, 19, 20). Soon, serious concerns appeared among orthopaedic surgeons and other HCWs regarding a lack of comparative efficacy, scientific evidence, compliance, shortage of materials and the side effects of PPE usage.

The EFORT board focused on PPE usage problems and implemented an initiative to improve orthopaedic ward and operating theatre protection for both orthopaedic and trauma surgeons and HCWs. We report the results of the initial survey which was developed as part of a problem-recognising process. The majority of the 695 responders were experienced European orthopaedic and trauma surgeons practising both trauma and elective surgery in national health systems (43.88%), in academic centres (32.23%) and in the private sector (19.86%). The vast majority (more than 80%) of these orthopaedic surgeons had come into contact with COVID-19-positive patients and recalled incidences of surgeons or HCWs developing COVID-19 symptoms in their departments. Moreover, half of the respondents had operated on COVID-19-positive patients. The above data clearly show the wide exposure and vulnerability of orthopaedic surgeons and relevant HCWs to the COVID-19 virus. The possible exposure and vulnerability of both general and orthopaedic and trauma surgeons have been previously reported (5, 6, 7, 8, 9, 19), but actual numbers and percentages for orthopaedic and trauma surgeons are first reported in this study.

The vast majority (more than 80%) of the respondents were well informed considering the general use of PPE for HCWs and were operating theatre surgeons. However, only half of them considered themselves informed about PPE for aerosol-generating orthopaedic procedures. The mechanism of COVID-19 virus transmission and the potential hazardous effects of aerosol-generating procedures for orthopaedic surgery (19, 20, 21, 22) and other surgical specialties (23, 24, 25, 26, 27, 28) have been well documented. However, it seems that information relating to their use is lacking, and more importantly, the efficacy of available PPE has been unclear (29). Surprisingly, the use of surgical helmets is questioned, and it is possible that they may even have a negative effect (21, 22). The vast majority (more than 80%) of our respondents confirmed that their hospitals had introduced satisfactory testing and different management pathways for COVID-19 and non-COVID-19 patients. Additionally, the majority confirmed the existence of relevant guidelines for the use of PPE on the wards, in clinics or in the operating theatres of their hospitals. Surprisingly, only 40% of the respondents confirmed the existence of guidelines for the use of PPE for aerosol-generating procedures when operating on COVID-19 patients. It seems that health authorities and hospital management introduced general guidelines



for the overall management of COVID-19 patients (5, 6, 7, 8, 9). However, it has become obvious that health authorities and management have not focused on and have not provided guidelines for the use of PPE in aerosol-generating orthopaedic and trauma procedures (20, 29).

Despite the introduction of guidelines for the general (wards and outpatient clinics) or specific (intra-operative) use of PPE, education about their appropriate use was lacking, since only 50% of the responders were trained to use them. No previous report has addressed this problem either in orthopaedic surgery or in other surgical specialties. The majority (more than 80%) of the respondents confirmed that simple PPE (such as masks, face shields, goggles and gloves) were available in the wards and clinics of their hospitals, but half of them recalled temporary shortages. When it comes to more specific PPE for orthopaedic operating theatres, availability was far lower. Shortages of either general or specific PPE during the pandemic have already been reported (27, 30).

The vast majority (87%) of our respondents confirmed that routine surface decontamination is performed on the wards, in the clinics and in operating theatres of their hospitals in line with recommendations and guidelines (8, 9, 19). Less than 50% of the respondents confirmed that the ventilation system in their operating theatres had been checked or improved in order to meet contemporary specifications and 35% of them were uncertain. The above data clearly show that hospital management and orthopaedic surgeons have failed to address operating theatre ventilation quality or to conform to recommendations and guidelines (8, 9, 19). The majority of the respondents confirmed that operating theatre PPE negatively affected their surgical activity in terms of visual impairment and impaired communication, also causing discomfort and fatigue as well as overall impaired surgical performance. All of the above-mentioned areas increase the cognitive load on the performing surgeon. This might negatively affect the quality of care and reduce PPE compliance if the surgeon perceives discomfort to be hampering surgical performance. The above data also clearly show that existing PPE is not adequately designed for orthopaedic and trauma surgery; this is an open field for further improvement (13, 14, 15, 16, 17). The limitations of PPE use have already been recognised in various surgical specialties (16, 17, 23, 24, 27, 29) and may explain the relatively low level (60%) of compliance with their use found in our study for both orthopaedic surgeons and staff. A small number (15%) of respondents confirmed that they had used modified PPE due to either PPE shortages or in an attempt to reduce virus transmission during aerosol-generating orthopaedic procedures. The use of modified PPE for orthopaedic surgery and other surgical specialties has already been reported (31, 32, 33, 34, 35), and future

research should be directed towards new developments and the study of their comparative efficacy.

The main limitation of this study is that it reports the results of a questionnaire consisting of 24 simple questions designed in a way to reveal clear answers from as many orthopaedic surgeons as possible. As a result, descriptive data are reported only with more advanced statistical evaluation being impossible. Another limitation is the diversity of the sample since the majority of the orthopaedic and trauma surgeons were highly experienced and working mainly in academic/University hospitals. The fact that we report data related to the use of PPE in orthopaedic and trauma surgery for the first time, the high number of respondents and the clarity of their answers are the main strengths of the study.

In conclusion, the COVID-19 pandemic has put not only patient but also surgical staff safety at centre stage. Apart from virus tests and basic hygiene protocols, the supply, compliance and safe use of PPE must not be overlooked in order to evaluate cognitive ergonomics for the surgical staff and thus ensure optimal surgical performance and patient safety.

#### ICMJE Conflict of Interest Statement

The authors declare that there is no conflict of interest that could be perceived as prejudicing the impartiality of this study.

#### Funding Statement

The survey and the publication of this article were funded by the European Federation of National Associations of Orthopaedics and Traumatology (EFORT).

#### Acknowledgement

The authors gratefully acknowledge Oscar Vispo at the EFORT Head Office for professional administration of the survey.

#### References

1. Zhou P, Yang XL, Wang XG, Hu B, Zhang L, Zhang W, Si HR, Zhu Y, Li B, Huang CL, *et al.* Discovery of a novel coronavirus associated with the recent pneumonia outbreak in humans and its potential bat origin. *Nature* 2020 **579** 270–273. (<https://doi.org/10.1038/s41586-020-2012-7>)
2. WHO. Coronavirus disease (COVID-19) pandemic. (available at: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>). Accessed on 22 April 2020.
3. Kort NP, Barrena EG, Bédard M, Donell S, Epinette JA, Gomberg B, Hirschmann MT, Indelli P, Khosravi I, Karachalios T, *et al.* Resuming elective hip and knee arthroplasty after the first phase of the SARS-CoV-2 pandemic: the European Hip Society and European Knee Associates recommendations. *Knee Surgery, Sports Traumatology, Arthroscopy* 2020 **28** 2730–2746. (<https://doi.org/10.1007/s00167-020-06233-9>)
4. Thaler M, Kort N, Zagra L, Hirschmann MT, Khosravi I, Liebensteiner M, Karachalios T & Tandogan RN. Prioritising of hip and knee arthroplasty procedures during the COVID-19 pandemic: the European Hip Society and the European Knee Associates

- Survey of Members. *Knee Surgery, Sports Traumatology, Arthroscopy* 2021 **12** 1–5. (<https://doi.org/10.1007/s00167-020-06379-6>)
- 5. Hirschmann MT, Hart A, Henckel J, Sadoghi P, Seil R & Mouton C.** COVID-19 coronavirus: recommended personal protective equipment for the orthopaedic and trauma surgeon. *Knee Surgery, Sports Traumatology, Arthroscopy* 2020 **28** 1690–1698. (<https://doi.org/10.1007/s00167-020-06022-4>)
- 6. Stewart CL, Thornblade LW, Diamond DJ, Fong Y & Melstrom LG.** Personal protective equipment and COVID-19: a review for surgeons. *Annals of Surgery* 2020 **272** e132–e138. (<https://doi.org/10.1097/SLA.0000000000003991>)
- 7. Jessop ZM, Dobbs TD, Ali SR, Combella E, Clancy R, Ibrahim N, Jovic TH, Kaur AJ, Nijran A, O'Neill TB, et al.** Personal protective equipment for surgeons during COVID-19 pandemic: systematic review of availability, usage and rationing. *British Journal of Surgery* 2020 **107** 1262–1280. (<https://doi.org/10.1002/bjs.11750>)
- 8. Wang Y, Zeng L, Yao S, Zhu F, Liu C, Di Laura A, Henckel J, Shao Z, Hirschmann MT, Hart A, et al.** Recommendations of protective measures for orthopedic surgeons during COVID-19 pandemic. *Knee Surgery, Sports Traumatology, Arthroscopy* 2020 **28** 2027–2035. (<https://doi.org/10.1007/s00167-020-06092-4>)
- 9. Fillingham YA, Grosso MJ, Yates AJ & Austin MS.** Personal protective equipment: current best practices for orthopedic teams. *Journal of Arthroplasty* 2020 **35** S19–S22. (<https://doi.org/10.1016/j.arth.2020.04.046>)
- 10. Rizan C, Reed M & Bhutta MF.** Environmental impact of personal protective equipment distributed for use by health and social care services in England in the first six months of the COVID-19 pandemic. *Journal of the Royal Society of Medicine* 2021 **114** 250–263. (<https://doi.org/10.1177/01410768211001583>)
- 11. Chiu CK, Chan CYW, Cheung JPY, Cheung PWH, Gani SMA & Kwan MK.** Personal protective equipment usage, recycling and disposal among spine surgeons: an Asia Pacific Spine Society Survey. *Journal of Orthopaedic Surgery* 2021 **29** 2309499020988176. (<https://doi.org/10.1177/2309499020988176>)
- 12. Prakash G, Shetty P, Thiagarajan S, Gulia A, Pandrowala S, Singh L, Thorat V, Patil V, Divatia JV, Puri A, et al.** Compliance and perception about personal protective equipment among health care workers involved in the surgery of COVID-19 negative cancer patients during the pandemic. *Journal of Surgical Oncology* 2020 **122** 1013–1019. (<https://doi.org/10.1002/jso.26151>)
- 13. McQueen SA, Hammond Mobilio MA & Moulton CE.** The person behind the personal protective equipment. *Annals of Surgery Open* 2020 **1** e004. (<https://doi.org/10.1097/AS9.000000000000004>)
- 14. Frountzas M, Nikolaou C, Schizas D & Toutouzias KG.** Personal protective equipment against COVID-19: vital for surgeons, harmful for patients? *American Journal of Surgery* 2021 **221** 772–774. (<https://doi.org/10.1016/j.amjsurg.2020.09.014>)
- 15. Yáñez Benítez C, Güemes A, Aranda J, Ribeiro M, Ottolino P, Di Saverio S, Alexandrino H, Ponchiatti L, Blas JL, International Cooperation Group on PPE and Emergency Surgery, et al.** Impact of personal protective equipment on surgical performance during the COVID-19 pandemic. *World Journal of Surgery* 2020 **44** 2842–2847. (<https://doi.org/10.1007/s00268-020-05648-2>)
- 16. Scarano A, Inchingolo F, Rapone B, Festa F, Tari SR & Lorusso F.** Protective face masks: effect on the oxygenation and heart rate status of oral surgeons during surgery. *International Journal of Environmental Research and Public Health* 2021 **18** 2363. (<https://doi.org/10.3390/ijerph18052363>)
- 17. Celtiki E, Karaaslan B, Börcek AÖ & Emmez OH.** Reduced field of view under the surgical microscope due to personal protective equipment: lessons learned during the COVID-19 pandemic. *Neurosurgical Focus* 2020 **49** E15. (<https://doi.org/10.3171/2020.9.FOCUS20370>)
- 18. WHO.** Rational use of personal protective equipment (PPE) for coronavirus disease (COVID-19) and considerations during severe shortages. Interim guidance, 2020. (available at: <https://www.who.int/publications-detail/rational>)
- 19. Basso T, Dale H, Langvatn H, Lønne G, Skråmm I, Westberg M, Wik TS & Witsø E.** Virus transmission during orthopedic surgery on patients with COVID-19 – a brief narrative review. *Acta Orthopaedica* 2020 **91** 534–537. (<https://doi.org/10.1080/17453674.2020.1764234>)
- 20. Geevarughese NM & Haq RU.** Aerosol generating procedures in orthopaedics and recommended protective gear. *Journal of Clinical Orthopaedics and Trauma* 2021 **12** 40–42. (<https://doi.org/10.1016/j.jcot.2020.08.019>)
- 21. Temmesfeld MJ, Jakobsen RB & Grant P.** Does a surgical helmet provide protection against aerosol transmitted disease? *Acta Orthopaedica* 2020 **91** 538–542. (<https://doi.org/10.1080/17453674.2020.1771525>)
- 22. Schaller G, Nayar SK, Erotocritou M, Overton A, Stelzhammer T & Berber O.** Efficacy of surgical helmet systems for protection against COVID-19: a double-blinded randomised control study. *International Orthopaedics* 2021 **45** 39–42. (<https://doi.org/10.1007/s00264-020-04796-3>)
- 23. Lee JC, Ozaki A & Ozaki W.** The impact of COVID-19 on the personal protective equipment practices and preferences of craniofacial surgeons. *Plastic and Reconstructive Surgery: Global Open* 2021 **9** e3686. (<https://doi.org/10.1097/GOX.0000000000003686>)
- 24. Alterman M, Nassar M, Rushinek H, Cohen A, Shapira L & Casap N.** The efficacy of a protective protocol for oral and maxillofacial surgery procedures in a COVID-19 pandemic area—results from 1471 patients. *Clinical Oral Investigations* 2021 **25** 5001–5008. (<https://doi.org/10.1007/s00784-021-03809-8>)
- 25. Iyer A, Tikka T, Calder N, Qamar SN & Chin A.** Effect of personal protection equipment (PPE) and the distance from the eye piece of surgical microscope on the field of vision; an experimental study. *Otology and Neurotology* 2021 **42** 606–613. (<https://doi.org/10.1097/MAO.0000000000002989>)
- 26. Clamp PJ & Broomfield SJ.** The challenge of performing mastoidectomy using the operating microscope with coronavirus disease 2019 personal protective equipment (PPE). *Journal of Laryngology and Otology* 2020 **134** 739–743. (<https://doi.org/10.1017/S0022215120001607>)
- 27. Moorthy RK & Rajshekhar V.** Impact of COVID-19 pandemic on neurosurgical practice in India: a survey on personal protective equipment usage, testing, and perceptions on disease transmission. *Neurology India* 2020 **68** 1133–1138. (<https://doi.org/10.4103/0028-3886.299173>)
- 28. Irons JF, Pavey W, Bennetts JS, Granger E, Tutungi E & Almeida A.** COVID-19 safety: aerosol-generating procedures and cardiothoracic surgery and anaesthesia – Australian and New Zealand consensus statement. *Medical Journal of Australia* 2021 **214** 40–44. (<https://doi.org/10.5694/mja2.50804>)
- 29. Key T, Mathai NJ, Venkatesan AS, Farnell D & Mohanty K.** Personal protective equipment during the COVID-19 crisis: a snapshot and recommendations from the frontline of a university teaching hospital. *Bone and Joint Open* 2020 **1** 131–136. (<https://doi.org/10.1302/2633-1462.15.BJO-2020-0027.R1>)
- 30. Kim H, Hegde S, LaFiura C, Raghavan M, Sun N, Cheng S, Rebholz CM & Seidelmann SB.** Access to personal protective equipment in exposed healthcare workers and COVID-19 illness, severity, symptoms and duration: a population-based case-control

study in six countries. *BMJ Global Health* 2021 **6** e004611. (<https://doi.org/10.1136/bmjgh-2020-004611>)

**31. Gibbons JP, Hayes J, Skerritt CJ, O'Byrne JM & Green CJ.** Custom solution for personal protective equipment (PPE) in the orthopaedic setting: retrofitting Stryker Flyte T5 PPE system. *Journal of Hospital Infection* 2021 **108** 55–63. (<https://doi.org/10.1016/j.jhin.2020.10.016>)

**32. Erickson MM, Richardson ES, Hernandez NM, Bobbert 2nd DW, Gall K & Fearis P.** Helmet modification to PPE with 3D printing during the COVID-19 pandemic at Duke University Medical Center: a novel technique. *Journal of Arthroplasty* 2020 **35** S23–S27. (<https://doi.org/10.1016/j.arth.2020.04.035>)

**33. Kim M, Lee M, Schwarz J, Kacker A & Schwartz TH.** A novel negative pressure, face-mounted antechamber to minimize aerosolization of particles during endoscopic skull

base surgery. *Operative Neurosurgery* 2021 **21** 131–136. (<https://doi.org/10.1093/ons/opab173>)

**34. Cacco T, Fragale M, Sampieri C, Castello E, Risso C, Piras MT, Durando P, Montecucco A, Pariscenti GL & Peretti G.** Modified full-face snorkeling mask for thoracic surgery and otolaryngology surgical use: comfort and usability assessment during the COVID-19 pandemic. *Medicina del Lavoro* 2021 **112** 107–114. (<https://doi.org/10.23749/mdl.v112i2.10032>)

**35. Patir R, Sreenivasan SA & Vaishya S.** Negative pressure assisted microenvironment surgical hood: a novel cost-effective device to minimize aerosol contamination During neurosurgical procedures in times of COVID-19. *World Neurosurgery* 2021 **150** 153–160. (<https://doi.org/10.1016/j.wneu.2021.03.055>)