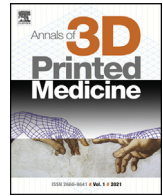




Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.



## Technical note

## 3D-printed shields for slit lamps produced during the COVID-19 pandemic



Maxime Delbarre<sup>a</sup>, Pierre-Marc François<sup>b</sup>, Jérémy Adam<sup>b</sup>, Jean-Baptiste Caruhel<sup>c</sup>,  
Françoise Froussart-Maille<sup>a</sup>, Roman Hossein Khonsari<sup>d,\*</sup>

<sup>a</sup> Service d'Ophthalmologie, Hôpital d'Instruction Des Armées Percy, Clamart, France

<sup>b</sup> Bone3D, Paris, France

<sup>c</sup> Service De Chirurgie Maxillofaciale, Hôpital d'Instruction Des Armées Percy, Clamart, France

<sup>d</sup> Service De Chirurgie Maxillo-Faciale Et Chirurgie Plastique, Hôpital Universitaire Necker – Enfants Malades, Assistance Publique – Hôpitaux De Paris, Centre De Références Maladies Rares Fentes Et Malformations Faciales MAFACE, Centre De Références Maladies Rares Craniosténoses Et Malformations Craniofaciales CRANIOST, Filière Maladies Rares TeteCou, Université De Paris, Paris, France

## ARTICLE INFO

## Article history:

Received 7 October 2020

Received in revised form 30 October 2020

Accepted 1<sup>st</sup> November 2020

Available online 23 November 2020

## Keywords:

COVID-19

FDM

ABS

Personal protection

Slit lamp

## ABSTRACT

Additive manufacturing has been extensively used during the COVID-19 pandemic to design and produce protection equipment. During clinical examinations using slit lamps, ophthalmologists are at risk of being contaminated by the SARS-CoV-2 virus, and the device itself is exposed to viral contamination. Several solutions have already been proposed for fixing transparent shields on the physician side. Here we propose a 3D-printed device fixed on the chin rest on the patient side, aiming at limiting viral spread both on the lamp itself and towards the physician.

© 2020 The Author(s). Published by Elsevier Masson SAS. This is an open access article under the CC BY license (<http://creativecommons.org/licenses/by/4.0/>).

## Introduction

Clinical examination using a slit lamp is at high risk of SARS-CoV-2 contamination due to the proximity of the physician with the face of his patient. Several types of home-made disposable protection screens were developed at the beginning of the COVID-19 pandemic (Fig. 1), located on the side of the physician [1]. Due to the need for long-term protection against the virus, we aimed at designing a permanent shield fixed on the chin rest, that could also be used in various devices without optics. This protective device aimed at preventing the patient side of the slit lamp from being contaminated.

## Technical note

The 3D COVID initiative, launched by the trust of Greater Paris University Hospitals (Assistance Publique – Hôpitaux de Paris, AP-HP) and Université de Paris, consisted in a platform of 60 professional Fused Deposition Modeling (FDM) 3D printers that allowed

fast prototyping and production in response to the pandemic. The design of the shield was performed by a group of dedicated engineers (BONE 3D, Paris) and prototypes were tested at Hôpital d'Instruction des Armées, Percy, Clamart, France (Fig. 2). The devices were printed on J120, J170 and J370 FDM machines from Statasys (Eden Prairie, MN, USA). Layer thickness was 0.33 mm, with a filling density of 32 % and a wall thickness of 2 mm. Average printing time was 2 h. The average price in raw materials for a single shield printed in acrylonitrile butadiene styrene (ABS) was 6.5 euros. The shield presented here was designed for Height Streit BQ 900 slit lamps (Fig. 3) and the STL files were made available for free on the dedicated website of the AP-HP / Université de Paris initiative.

## Discussion and conclusion

During the COVID-19 pandemic, an urgent need for protection devices triggered the fast development of 3D printing initiatives [2,3]. Several types of devices share a global common structure but needed slight specific shape variations for each model, such as hand-free door openers adapted to different types of door handles [4] or protection shields for slit lamps. For these specific cases, where several nearly similar models were required in moderate quantities (several hundreds to several thousands), injection moulding was not an adequate technique due to the need of a series

\* Corresponding author at: Service de chirurgie maxillo-faciale et chirurgie plastique, Hôpital Universitaire Necker – Enfants Malades, 149 rue de Sèvres, 75015 Paris, France.

E-mail address: [roman.khonsari@aphp.fr](mailto:roman.khonsari@aphp.fr) (R.H. Khonsari).

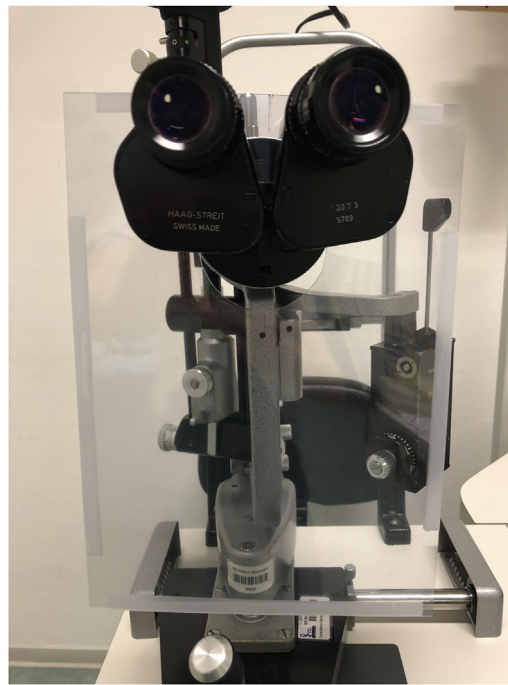


Fig. 1. Transparent home-made protective shield on a slit lamp on the physician's side.

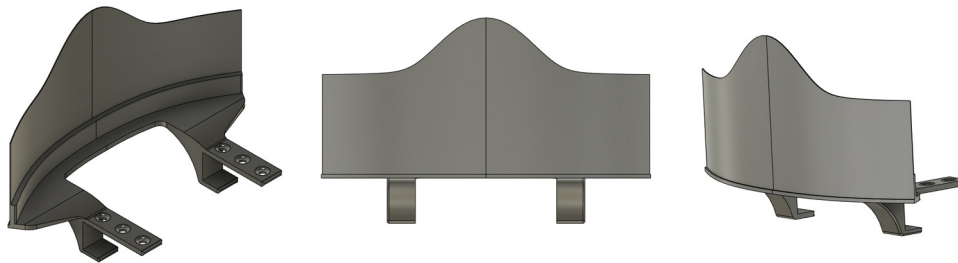


Fig. 2. Design of a protection device to be fixed on the chin rest of Height Streit BQ 900 slit lamps, in order to protect the patient side and the physician.

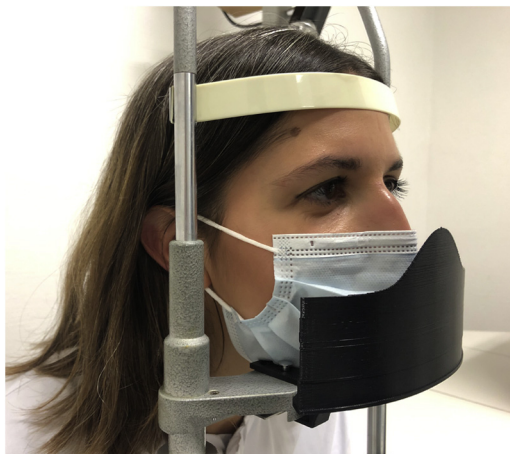


Fig. 3. Device positioned on a Height Streit BQ 900 slit lamp on the patient side.

of different moulds that would each be used for limited production numbers. In this context, 3D printing was an ideal technique and was specifically adapted to respond to the need of protection devices for slit lamps in different ophthalmology departments within AP-HP and other hospitals such as Hôpital d'Instruction des Armées, Percy.

Regarding the specific case of the shield for slit lamps, two engineers from 3D COVID were sent onsite at Hôpital d'Instruction des Armées, Percy in order to collect data on the chin rest of the Height Streit BQ 900 slit lamp. After several minor adjustments performed based on exchanges with the 3D COVID engineering team, a final design was approved by ophthalmologists with 24 h and produced in 15 copies that could be used without major technical issues.

Of note, it has recently been shown that SARS-CoV-2 can survive up to 72 h on plastic surfaces [5] and that a large range of surfaces within hospitals carry viruses [6]. We propose that the 3D-printed shield should be cleaned after every clinical examination of a different patient by 62 to 71 % ethanol, 0.1 % to 0.5 % sodium hypochlorite or by commercial products responding to the EN14476 norm (virucidal activity in the medical area). ABS is compatible with such treatments.

#### Declaration of competing interest

None.

#### References

- [1] Wong DHT, Mak ST, Yip NKF, Li KKW. Protective shields for ophthalmic equipment to minimise droplet transmission of COVID-19. *Graefes Arch Clin Exp Ophthalmol* 2020;258:1571-3, <http://dx.doi.org/10.1007/s00417-020-04683-y>.

- [2] Amin D, Nguyen N, Roser SM, Abramowicz S. 3D printing of face shields during COVID-19 pandemic: a technical note. *J Oral Maxillofac Surg* 2020;78:1275–8, <http://dx.doi.org/10.1016/j.joms.2020.04.040>.
- [3] Erickson MM, Richardson ES, Hernandez NM, Bobbert 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. *J Arthroplasty* 2020;35:S23–7, <http://dx.doi.org/10.1016/j.arth.2020.04.035>.
- [4] François PM, Bonnet X, Kosior J, Adam J, Khonsari RH. 3D-printed contact-free devices designed and dispatched against the COVID19 pandemic: the 3D COVID initiative. *J Stom Oral Maxillofac Surg* 2020, <http://dx.doi.org/10.1016/j.jormas.2020.06.010>.
- [5] van Doremalen N, Bushmaker T, Morris DH, Holbrook MG, Gamble A, Williamson BN, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *New England J Med Surg Collat Branches Sci* 2020;382:1564–7, <http://dx.doi.org/10.1056/NEJMc2004973>.
- [6] Wu S, Wang Y, Jin X, Tian J, Liu J, Mao Y. Environmental contamination by SARS-CoV-2 in a designated hospital for coronavirus disease 2019. *Am J Infect Control* 2020;48:910–4, <http://dx.doi.org/10.1016/j.ajic.2020.05.003>.