Article

COVID19-Personal Protective Equipment ergonomic improvements: necessary considerations for the dental team health

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Abstract

The coronavirus disease (COVID-19) caused by the SARS-CoV-2 coronavirus impacted worldwide without any precedents, including the dental world, from the education to the advanced cares. The co-existence with the virus circulation imposed the use of personal protection equipment such as respiratory protective equipment. The aim of this paper is to report the modifications made to a Power Air Power Respirator to improve the quality of work during dental hygiene procedures. The device is composed of a hood and a power-air unit. The power-air unit is equipped with a strap to secure the filters and battery at the waist. The hood and the power-air unit presented visibility, weight, and use issues during dental hygiene procedures. The modifications to the hood made the shield more resistant and allowed the place for magnifying loupes. In addition, placing the battery-unit in a backpack, the weight was better distributed. Further innovations in PPE, barrier devices to minimize aerosol contamination, air purification systems, antiviral adjuvants, chairside screening for COVID-19, changes in clinical techniques could be envisaged to minimize the spread of COVID-19, possibly adapted, and adopted in future pandemics.

Key words: COVID-19; prevention & control; dentistry; dental hygiene; occupational exposure.

Introduction

The coronavirus disease (COVID-19) caused by the SARS-CoV-2 coronavirus has had an unprecedented impact worldwide[1]. However, the nature of the virus spreading modality, no single strategy could limit the pandemic diffusion, requiring a continuous struggle by even the most advanced healthcare systems to address the challenges of COVID-19.

COVID-19 disease began in December 2019 in the Wuhan fish market in China and then rapidly spread to Thailand, Japan, South Korea, Singapore, and Iran. Subsequently, the viral spread affected Italy, Spain, the USA, the UAE, and the UK[2]. Therefore, the rapid spread of the disease led the World Health Organisation (WHO) to define COVID-19 as a pandemic on 11 March 2020[3]. Significant challenges have followed since then, with virus isolation, an effective vaccine development towards the multiple variants, and appropriate disease management as the main objectives.

In terms of structure, COVID-19 is an RNA virus, thus more prone to changes and mutations than DNA viruses, which are single-stranded positive with an envelope.

The viral genome has a 5' terminal rich in open reading frames that encodes proteins essential for virus replication. Instead, the 3' terminal includes five structural proteins, Spike protein (S), membrane protein (M), nucleocapsid protein (N), an envelope protein (E), and haemagglutinin-esterase protein (HE). The Spike protein is mainly responsible for pathogenesis in the human species because its receptor-binding domain (RBD) binds to the human cell surface receptor protein Angiotensin-converting enzyme - 2 (ACE - 2), encoded by the ACE2 gene[4]. It then binds to the transmembrane protease serine-2 (TMPRSS2), a cell surface protein expressed by epithelial cells of specific tissues[4]. The ubiquitous distribution of ACE - 2 in organs means that SARS-CoV-2 infection may mainly affect the lungs, leading to respiratory failure. However, this infection involves several organs, from the kidneys to the heart, blood vessels, liver, pancreas, and immune system. Moreover, virus entry into host cells enhances the immune response, producing a profound secretion of inflammatory cytokines and chemokines, inducing acute respiratory distress and multi-organ failure[2,4,5].

SARS-CoV-2 has been found in nasopharyngeal secretions and saliva. Thus, the infection spreads mainly through respiratory droplets and direct contact with infected individuals and inanimate objects[6].

SARS-CoV-2 can likely spread through aerosols (usually defined as small airborne particles <5μm) generated during dental procedures, reaching considerable distances and even remaining suspended in the air for several hours, making the dental office environment a high-risk area for nosocomial spread[7–12].
Until the development and delivery of an effective vaccine against COVID-19, the first measures affected dental care treatments, which were limited to emergency treatment in most developed countries[13,14].
For the protection of patients and all the dental team, in-office consultation was restricted to a selected group of patients after appropriate risk assessment. In addition, appropriate physical and temporal separation measures have been implemented in dental practices, and adequate time was set aside for clearance and decontamination of the working field between patients[15].
The global protocols for clinical dentistry during COVID-19 showed a widespread and broad consensus on the observance of proper and thorough hand hygiene and appropriate personal protective equipment (PPE)[16]. Recommended PPE included disposable gowns, gloves, FFP2 or FFP3 masks or N95 masks, and appropriate eye protection[13,17].
Additional measures suggested during operational procedures included using high-volume suction devices, rubber dam isolation, and mouthwashes with 0.2% chlorhexidine before the procedure to reduce the viral load in the oral cavity[18].
The adopted measures have been proved effective in limiting the virus diffusion[19].
According to dental procedures, different types of PPEs are required. For example, the procedures generating aerosol, such as dental hygiene procedures, require the use of a cap, protective glasses or face shield, FFP2 or FFP3 mask, Uniform, Fluid-resistant gown, Gloves, Clinical footwear, and shoe covers[13]. Dental health care professionals have also considered the Powered Air-Purifying Respirator (PAPR) as alternative PPE when in shortages of FFP2 masks[14,20].
The PAPRs usually are composed by a hood which can be loose or tight fit type, or a rigid helmet, and by a battery-powered unit which filter and purify the air, breathed by the user. These devices have been considered during the early stages of the pandemic, also by the dental workers, due to the shortages of PPE supplies[16,17]. However, the ergonomics and the costs lower the quality of life of the dental professionals during the procedures.
This paper aims to report the modifications made to a PAPR to improve the quality of work during dental hygiene procedures.

PAPR defects and proposed solutions

The device is composed of a hood and a power-air unit. The power-air unit is equipped with a strap to secure the filters and battery at the waist. The hood and the power-air unit presented visibility, weight, and use issues during dental hygiene procedures. The power-air unit aims to filter the air in the hood to guarantee protection against the external droplets generated during the aerosol procedures. However, the air outlet led to two problems: 1) the device would go into alarm when catching the hair (even under the cap), 2) the air was directed over the neck and sometimes into the ear.

The hood

The object of the study is the product 'K20 hood 0326003' manufactured by KASCO SRL (Reggio Emilia, Italia), which conditions were found to improve its durability. After short periods of use, indeed, cracks appear along the perimeter path from the transparent visor (Figure1) and scratches on the inside due to friction on the inner surface from magnifying glasses (Figure 1). Therefore, two essential features of the usage: the separation with the outside and its unfiltered, positive-pressure leakage from the front (perimeter cracking) and blurring of visibility (scratch marks from magnifying glasses).
The two critical points are due to the considerable lightness and flexibility of the cover that provides comfort and considerable deformation in operation, inducing creases in the visor and impacts with the glasses.
Although a material of remarkable plasticity, the transparent polycarbonate shield is weakened by the seam

Figure 1. A. Cracks on the edge of the v sor and B. scratches due to magn fy ng g asses.

2 mm from the edge, binding it to the rest of the device. It also takes on the burden of anchoring the support for wearing. Moreover, the construction system does not provide for the visor replacement by the operator. A replacement or any other intervention leads to the loss of certification (EN 529:2006). Therefore, the user has to resort to a new and costly purchase.

The goal is to make the visor less perishable and replaceable simply and efficiently to make the general maintenance exclusively based on sanitization.

To obtain our prototype, we thought of providing the visor with a PETG frame as slender as possible to provide stiffening and anchorage in strict mode towards the fabric of the cover and in removable by screws towards the transparent visor. Furthermore, the same frame is entrusted with the anchorage of the support for wearing (Figure 2).

This modification provides excellent stability in the distance from the face during the movements, avoiding abrasions due to impact from the glasses magnifying glasses (Figure 3). Furthermore, leakage to the outside is ensured with a thin rubber gasket compressed by the pressure of the visor transparent polycarbonate visor on the frame, an action exerted by a series perimeter of M3 nylon screws (Figure 2). However, this stiffening creates problems with air intake at the rear. Moreover, with the helmet's oscillation reduction, the tube becomes stiffened at the outlet and can find an obstacle in the hair or the cap. To overcome this latter handicap, the inner ring nut of the inlet pipe with a radial diffuser

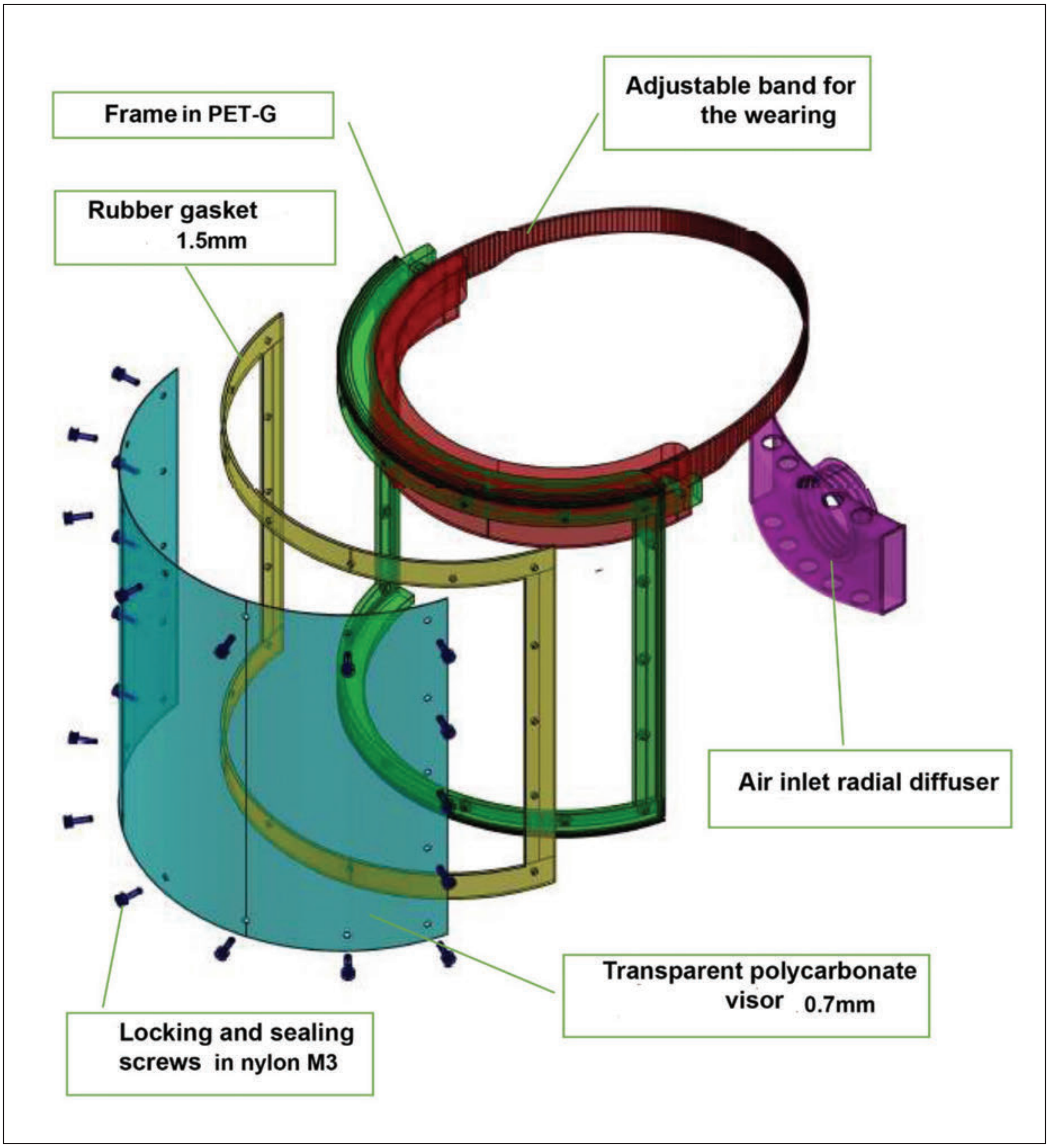

Figure 2. Exp oded v ew of the construct on deta s re at ng to the mod ficat on (exc ud ng the band for the wear ng that comes reused)

Figure 3. Worn hood: space for magn fy- ng oupes ava ab e.

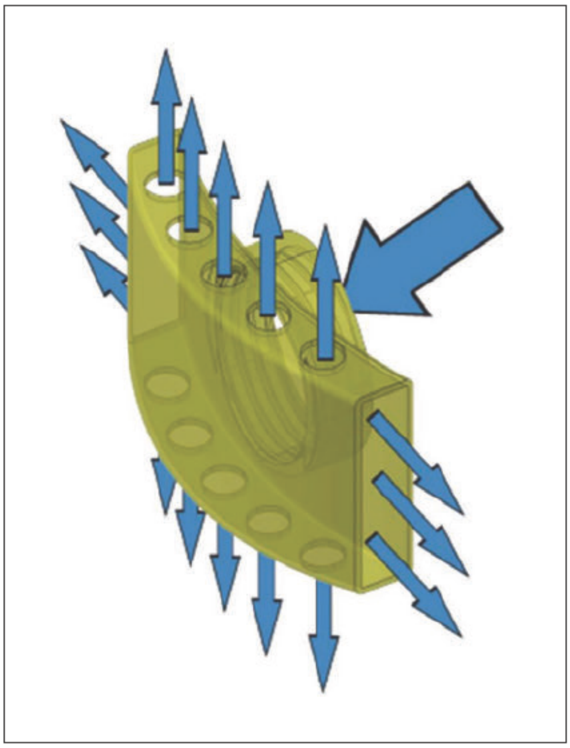

Figure 4. KometB o's Smart Dent n Gr nder w th the extracted and c eaned teeth nserted nto the gr nd ng chamber.

feeds the helmet in areas free of obstacles (Figure 4). This way, disposal would be reduced to the transparent visor alone, which provides a longer return time with an ecological advantage (Figure 5)

Figure 5. F na v ew of the frame w th the v sor.

Figure 6. A. the battery un t s p aced at the wa st, w th mba ance of the posture. B the battery s n the backpack, d str but ng the we ght on the upper port on of the trunk.

The power-air unit

The unit is placed at the waist and therefore the weight is on the lower back, influencing the posture and possibly accentuating musculoskeletal problems (Figure 6).
The proposed solution included placing the power unit into a small backpack to balance the weight and help it reach a symmetrical posture (Figure 6).

Discussion

This study reported the modification of a PAPR to make it more ergonomic during the dental setting. As stated, PPE use is fundamental in dental procedures, and the initial scarcity of supply made professionals look towards other equipment to work ethically.
The available and adequate PPEs for dental procedures are respiratory protective equipment (RPE) which protects both the patient and the wearer. The RPE filter the air and, most importantly, needs to seal to the wearer's face to offer optimal protection[17]. The whole dental team tolerates RPE well since the habit of wearing the surgical mask before the pandemic and working close to the mouth and the upper respiratory tract[21].
The use of PAPRs during the dental procedure has been tested by Oakes et al., who evaluated its uses in dental hygiene, restorative dentistry, and surgeries and the feedback from the dental team[20].
The positive outcomes from their surveys suggested a place for PAPRs in the dental community, especially the dental hygienists who preferred it and gave feedback on feeling more protected.
The hood of PAPR does not require a fit test such as the N95, and due to the size and shape, people who do not fit the N95 can be protected[20].
PAPRs improve the overall respirator quantity and own an Assigned Protection Factor ranging from 25 up to 1,000[17]. The hood of PAPRs protects hair, face, eyes, and neck from the droplets and lowers the necessity for additional PPE (caps, bouffants, goggles, and surgical masks)[20].
In the study of Oakes et al., the use of magnifying loupes has been questioned, raising the issue of the space available to wear the magnifying system and the costs of the disposable hood[20].
The modifications proposed in our report overcame these issues, allowing the space for the magnifying loupes and decreasing the cost of replacing the shield.
The COVID-19 pandemic has brought economic and social adverse effects and highlighted the vulnerabilities of modern healthcare infrastructures[7]. The urgency to produce scientific evidence on coronavirus disease has inevitably exceeded existing systems, catching medical scientists by surprise, opening new questions about our preparedness and the need for updated protocols for pandemic management.
In this framework, the use and the development of new and more performing PPE guarantee the health of the patients and operator. Among the proposed PPE, the NOVID system (negative pressure otorhinolaryngology viral isolation drape) promises to limit aerosol contamination during surgical procedures performed under general anesthesia in the operating room environment[22].

Although the use of this device on conscious patients in dental practices is unlikely in its current form, it opens the door to innovation in the development of barrier systems[23]. For example, in the study by Alì and Raja[24] fluorescein dye and ultraviolet (UV) light were used to limit aerosol diffusion during operative dentistry.
Further innovations in PPE, barrier devices to minimize aerosol contamination, air purification systems, antiviral adjuvants, chairside screening for COVID-19, and changes in clinical techniques could be envisaged to minimize the spread of COVID-19, possibly adapted, and adopted in future pandemics.

Conflict of Interest

None

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