International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

Difficulties Encountered using Optical Magnification in Microsurgery with Personal Protection Equipments Amidst the COVID-19 Era. Is there a Possible Solution?

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Abstract: ***Introduction: COVID-19 pandemic has posed great difficulties in management of surgical patients. The use of standard Personal Protection Equipments (PPEs) has been mandated for all health care workers including the surgical team. In the field of Microsurgery, where specific devices for optical magnification, like the surgical loupes or microscopes, have to be used, surgeons are facing great difficulties, in addition to general problems for all surgical disciplines. Aims and objectives: To categorize the specific problems faced during repair and reconstruction using optical magnification devices and to offer and propose some technical solutions for the same. Methodology: This is a retrospective descriptive institutional study over 10 patients warranted for urgent microsurgical procedures over 1 month in 2 tertiary care hospitals. As per guidelines for executing surgical procedures in this scenario, 10 patients were operated for acute trauma or malignancy using surgical loupes or operating microscopes in addition to using the standard available PPE like the Visor masks, N-95 respirators etc. The operative techniques using different devices were analyzed and the difficulties encountered were categorized with temporary ways of dealing with them and possible solutions (if any) are offered. Results: Out of the 10 patients operated, 3 were due to head and neck malignancy excision and reconstruction and the others due to acute trauma (mean age 50.6 years with male female ratio of 7:3). N-95 respirators were used in 6 cases and Visor mask face shields in the other 4 cases. Loupes were used in 7 cases and operating microscope in 3 cases. Vessel wall repair or anastomosis was done in 5 cases and nerve repair or coaptation in 3 cases. Minimum use of electrosurgical instruments (Monopolar diathermy in 4 cases and Bipolar in 9 cases) was advocated for haemostasis. In majority of the cases, blurring of magnified fields, fogging of the optical devices was encountered along with breathing difficulties. Conclusion: Executing microsurgery with optical magnification using the standard PPEs amidst the COVID-19 era causes immense problems of vision. There should be a rational approach to modify designs of the protective face and neck equipments specifically for the microsurgeons.***

Keywords: Microsurgey in COVID-19, optical magnification with PPE

1. Introduction

The year 2020 has been disastrous globally owning to the COVID-19 pandemic. Routine life and every activity have come to a standstill. Amidst such circumstances it is a nightmare for the healthcare workers to work day in and day out. Emergency and urgent surgical procedures carried out in such circumstances always possess a life threatening risk to everyone around including great challenges and difficulties to the operating surgeon. Several guidelines of surgical interventions have been proposed and modified accordingly. Quarantine measures of positive and high risk patients, use of personal protection equipments (PPEs), donning and doffing of the same, extra hygienic measures, social distancing and the nation wise lockdown issues have been the severe tantrums. [1, 2, 3]

The aerosol generated during usage of energy instruments carry substantial risks of spread of infection to the surgeon and team as well as others through central air conditioning vents. Hence selection of surgical cases in such times is based on essential and urgent indications only as surgery may accelerate and exacerbate disease progression of COVID-19 patients (in existing disease). Whether malignancy extirpations is indicated in such times is a matter of debate as postponing them would cause upstage of the disease process. Also palliative operations are essential to be carried out. Tumor or trauma causes defect and warrants the need for microsurgical reconstruction mostly at the same stage of resection or debridement. [4-10]

Ideal PPEs used in such circumstances consist of the N95 respirators and surgical masks (face masks) with or without face shields, coverall or gowns to protect the body with or without a separate hood for the head and neck (space-suit design), laboratory type goggles for the eyes, 2 layers of gloves for hands and forearms, rubber boots and often a heavy plastic apron in front. [11-15] The design and quality control of the N95 respirators are being regulated by Centers for Disease Control and Prevention (CDC), National Institute for Occupational Safety and Health (NIOSH) and Occupational Safety and Health Administration (OSHA) to block at least 95% of particles >0.3 micron size. While surgical masks (properly fitted) may be used for protection against splashes and large particle droplets, they fail to block the smaller particles and are intended for single use

(disposable). [13] Powered air purifying respirators (PAPR) may be used while intubation during induction and also reversal of anesthesia. [4, 13, 16, 17] FIGs. 1-A, B, C, D shows such PPEs used.

At the onset of this pandemic of COVID-19 virus globally, specific guidelines have been framed by the SAGES (Society of American Gastrointestinal and Endoscopic Surgeons) and the EAES (European Association for Endoscopic Surgery). [14] All elective surgical and endoscopic cases should be postponed (unless it is urgent and life threatening to the patients), all non-essential hospital or office staff should stay at home and do telework, all non-urgent in-person clinic/office visits should be cancelled or postponed, unless needed to triage active symptoms or manage wound care, multidisciplinary team (MDT) meetings should be held virtually as possible and/or limited to core team members only, including surgeon, pathologist, Clinical Nurse Specialist, radiologist, oncologist and coordinator. [14] There is very little evidence regarding the relative risks of Minimally Invasive Surgery (MIS) versus the conventional open approach, specific to COVID-19. [8] Regarding all surgical procedures, consent discussion must cover risk of COVID-19 exposure, patients with high risk including those with history of travel, contact with positive cases and showing symptoms of fever and diarrhea/ shortness of breath/ cough [5] (if practically feasible all pre-surgical patients) should be pre-operatively tested for COVID-19, intubation and extubation of anesthesia should be done in separate negative pressure rooms, only essential staff to be sanctioned in the OR (operating room), all members of OR staff should use PPEs as per CDC guidelines, [13] electrosurgery units to be set to lowest possible settings (minimum use of monopolar diathermy, harmonic and ultrasonic dissectors), proper evacuation of smoke to be ensured and separate cleaning and sterilization of instruments for COVID-19 positive cases should be facilitated. Also advanced ventilation systems like Ultra-Low Particulate Air (ULPA) and HEPA filters placed in OR ceilings provide safety. [14]

In reconstructive and trauma surgery, use of optical magnification is imperative. [18,19] Binocular loupes (with magnification of 2.5x to 5x) and microscopes (with magnification of 6x to 40x) are essential devices [FIGs. 1-E,F] for enhanced tissue visualization, appreciation of precise anatomical details, easier and precise placement of sutures, appreciation of tiny neurovascular structures, better resection of tumor with adequate margins and better positioning. [18-22] However carrying out procedures in high magnification on a routine basis is a great predicament for every case in perspective of COVID-19 pandemic, taking all the required measures like donning and doffing of cumbersome PPEs and modifying the methods of tissue dissection with minimum use of electrosurgical instruments emitting smoke fumes.

Figure 1 (A, B, C, D): Special PPEs used (A- N-95 mask, B- face shield, C- Visor mask, D- total suit, 1. E,F- devices for optical magnification in microsurgery (E- surgical loupe, F- operating microscope).

2. Methodology

This is a retrospective, descriptive, institutional study conducted at the Department of Burns and Plastic Surgery, AIIMS, Bhubaneswar, India and at the Department of Plastic Surgery, Apollo Gleneagles Hospital, Kolkata, India over 1 month (June 2020 to July 2020). The aims of this study is to define and categorize the difficulties experienced in using optical magnification devices at reconstruction and repair of cases due to trauma or oncology (which warranted surgical intervention on an urgent basis) using the standard PPEs available at our set up, and to propose any solution as a pilot project. No randomization of the study patients was done. Convenience sampling was adopted for case selection. Patients with traumatic injuries and following tumor excision who needed repair and reconstruction using magnification were included. We have not included cases (operated using PPEs) where no magnification was used. Informed consents were taken after explaining procedure details to patients and their attendants. The pre-anesthetic check up was done including history of travel in the last 2 weeks, close contact with any COVID-19 positive cases and any fever with any one symptoms of cough, shortness of breath or diarrhea with a close observation of the chest skiagram (PA view). [5] The decision of the Anesthesia and Infection control teams was taken to be the final regarding operability. Our next step was to choose the appropriate PPE gear for the surgery. Operating room personnel were reduced to essential staffs. A separate room with negative pressure ventilation with a separate entrance was designated for induction and another such room with separate exit designated as post-operative recovery room. We used N-95 respirators or double masks (inner one a standard surgical

mask and outer one as a Visor mask as a protective gear for face and a long disposable apparel (below knee) with double gloves and plastic shoe cover for the cases. Protective goggles were not used by us as we thought it would interfere with the already existing optical magnification system. Only a Visor face shield was used in some cases (Face shields with helmet head bands, surgical helmet system- SHS, body exhaust system- BHS or the space-suits were not available till the time of our study). [15] The induction of anesthesia was done rapidly with certainty in one shot in most of the cases by senior anesthetists in the Induction room with their standard PPE. The patients were shifted into the OR and cleaning and draping done following positioning. We avoided energy instruments to a maximum possible extent. Bipolar diathermies with low settings were preferred over monopolar, Ultrasonic or harmonic devices were not used in any case, rapid and effective evacuation of the smoke generated was executed by a dedicated scrub nurse or technician. The ORs had negative pressure ventilation. Careful donning and doffing of the operative apparels and their disposal were done (with previous institutional mandatory training sessions). [23] Tracheostomy was avoided in all cases except 1 case with free microvascular tissue transfer. The OR including surgical magnification system consisting of loupes or microscopes were carefully handled and disinfected using hydrogen peroxide vaporizer. [4] The difficulties of vision using the magnification system were noted (fogging of the refractive media from the surgeon's ends impairing visibility, difficulty in breathing, minimum use of electrocautery, rapid evacuation of smoke generated etc.) and documented. The post-operative care was standard with proper hand hygiene, use of surgical masks and social distancing, minimizing the number of visitors.

3. Results

Out of the 10 patients operated in one month in the middle of COVID-19 pandemic (April-May 2020), with male female ratio of 7:3, with a mean age of 50.6 years (16 to 86 years range), 7 patients had traumatic etiologies (acute trauma) and 3 patients had oro-mandibular malignancies (requiring urgent resection of the primary lesions). The mean operative time was 3.5 hours and the mean period of post-operative hospital stay was 4 days. In terms of PPE use for all surgical team members, Visor masks were used in 4 cases and N-95 respirators were used in 6 other cases. Microscopes were deployed in 3 cases and the remaining 7 cases were managed with Surgical Loupes (Binocular) with 4x magnification for both surgeon and first assistant. Microvascular anastomosis and repairs were done in 5 cases and nerve coaptation and repair in 3 cases. Bipolar diathermy was used in 9 cases and monopolar in 4 cases with minimum energy settings. In no case Ultrasonic or harmonic devices were used. Regarding induction of anesthesia, tracheostomy was done in 1 case with free flap reconstruction of oral malignancy defect while difficult intubation with multiple attempts was encountered in 3 cases. Regarding the difficulties of vision using the optical magnification along with PPEs, fogging and obscured vision was encountered in 8 cases (mostly the cases with Visor masks) with an average of 3.5 times changes of masks or their re-application with loupes per case. Difficulty in breathing was encountered by surgeons and first assistants in 5 cases mostly with the use of N95 respirators with frequent breaks being taken in between. In 2 cases N95 respirators had to be replaced with standard surgical masks after the energy device usage was more or less over. In most of the cases, pre-incision adrenaline (1:100000) infiltration was done and small vessels were clipped with 100 or 200 ligaclips avoiding bipolar or monopolar haemostasis as far as possible. The average time for haemostasis was increased per case owning to restricted electrosurgical device usage. There had to be a dedicated scrub nurse or technician to place the suction device in the operative field at the time of using monopolar or bipolar diathermies. This also increased the duration of surgeries. Proper doffing and discarding of the operative apparels and masks had to be ensured in each case and OT devices including the microscopes and the loupes used, had to be decontaminated using hydrogen peroxide vaporizer. The patient details, surgical details, types of PPEs used with magnification is given in TABLE-1.

Table 1: Showing the patient details, the surgical details and the magnification devices with type of PPEs used

S.No	Age (years)	Gender	Diagnosis	Microsurgical procedure	Magnification used and type of PPE used.
1	62	M	Traumatic injury left lower extremity with tibial # and posterior tibial vessel injury.	Repair of posterior tibial artery with 10-0 prolene suture apart from repair of muscles and fixation of # tibia	Surgical loupe with Visor mask.
2	54	M	Right sided CA gingivobuccal sulcus and alveolus	Free radial artery forearm flap to resurface oral and palatal defect following wide local excision and neck dissection.	Microscope used with N95 respirator.
3	32	F	Left forearm trauma with severed median nerve.	Coaptation of median nerve and repair of tendons.	Microscope with Visor mask.
4	48	M	Lt. CA mandible	PMMC flap to resurface defect following wide local excision and neck dissection.	Surgical loupe with N95 respirator.
5	66	F	Left limb trauma with both bone #, avulsed deep peroneal neurovascular bundle and partial tear of tibial nerve.	Coaptation of deep peroneal and tibial nerves, repair of peroneal vessels with repair of muscles and fixation of bones.	Surgical loupes with Visor mask.
6	16	M	Right sided traumatic injury of thumb and index fingers.	Repair of injured extensor tendons, terminalisation of index finger with Atasoy V-Y flap.	Surgical loupe with N95 respirator.
7	35	M	Trauma in bilateral lower limb with left limb posterior tibial artery and tibial nerve injury.	Repair of neurovascular structures and tendons.	Microscope with N95 respirator.

8	49	M	Left sided CA gingivobuccal sulcus and buccal mucosa.	PMMC flap following wide local excision and neck dissection.	Surgical loupe with Visor mask.
9	58	F	Trauma in right index finger with avulsed terminal phalanx.	Terminalisation of digit.	Surgical loupe with N95 respirator.
10	86	M	Trauma in right forearm with severed radial artery.	Radial artery repair.	Surgical loupe with N95 respirator.

4. Discussion

This was a retrospective descriptive study over 10 patients at both institutes over 1 month after the declaration of COVID-19 pandemic (June- July, 2020). 70% were males, mean age was 50.6 years (range 16-86 years), etiologies due to acute trauma were 70%, the rest 30% being malignancy surgeries. The mean operative time was 3.5 hours and the mean period of post-operative hospital stay was 4 days. PPEs in the form of Visor masks or N-95 respirators were used in all cases with the former being used in 40% cases and the latter in remaining 60% cases. Apart from this, double pair of surgical gloves, extra plastic apron apparel (till below knee level), shoe covers were used. No surgical goggles were used. Monopolar diathermies were used in 40% cases and bipolar used in 90% cases with minimum energy settings. Microvascular anastomosis or repair of vessels was done in 50% cases while nerve repair or coaptation done in 30% cases. There was difficult intubations encountered in 30% of the cases and in 10% cases tracheostomy had to be done. Regarding the difficulties of vision using the optical magnification along with PPEs, fogging and obscured vision was encountered in 80% cases (mostly the cases with Visor masks) with an average of 3.5 times changes of masks or their re-application with loupes per case. Difficulty in breathing was encountered by surgeons and first assistants in 50% cases mostly with the use of N95 respirators with frequent breaks being taken in between. In 20% cases N95 respirators had to be replaced with standard surgical masks after the energy device usage was more or less over. Ligaclips (No. 100 and 200) and adrenaline (1:100000) pre-infiltration in the proposed sites of incisions were used more frequently for haemostasis minimizing the use of bipolar and monopolar diathermies.

Problems categorized and our temporary solutions-

1) Obscured vision with N-95 respirators with specific spectacle mounted customized loupes (the horizontal nasal bridge of the spectacle often interferes with the apex of the hard N-95 masks), for which we had to use head band mounted loupes.
2) Intermittent fogging of the Visor mask face shield transparent plastic for which we had to replace the masks with frequent breaks in between (as the upper plastic shield of the mask is in continuity with the upper edge of the filtration cloth, there is no such way to minimize this problem with this particular mask as the upper end of mask cannot be adhered to the nasal bridge with leucoplast or durapore, sealing off the exhaled moisture bearing air passing out)
3) Also with surgeons using spectacles to correct their vision, the spectacle glasses within the Visor mask added an extra refractive medium to build up the fog in layers.
4) Using loupe or microscope over the Visor plastic shield introduces a separate refractive medium which causes disturbances in focusing on the surgical field. To tackle this problem the hand held focus button of microscopes could be used if there is difficulty for a single user but at the same time this causes difficulty to the assistant in case of dual or multiple user eye pieces. Also the built up fog inside the Visor mask face shield was a constant challenge which compelled us to take breaks or replace the mask intermittently.
5) There was significant breathing difficulty in using the tightly fitted N-95 masks specifically for the whole surgical team.
6) The smoke generated (although minimum due to minimum use of electrodissection instruments) had to be dedicatedly sucked in through a suction device by a scrub nurse or technician resulting in too many instrumentation in the operative field with space constraint. Diathermy pencils with attached cup sucker might help in such circumstances.
7) Although we have not used the space suit design of PPE with a helmet type of shield [12,15], it is contemplated to cause the same sort of problem if a surgical loupe is used inside or a microscope eye-piece outside, additionally causing more breathing difficulties without an oxygenator inside. Also there might be glare from the light source of loupes (if used) which is reflected onto the transparent plastic of the frontal aspect of the hood causing problems in vision.

FIGs 2 and 3 is used to depict the optical magnification difficulties with PPEs for face.

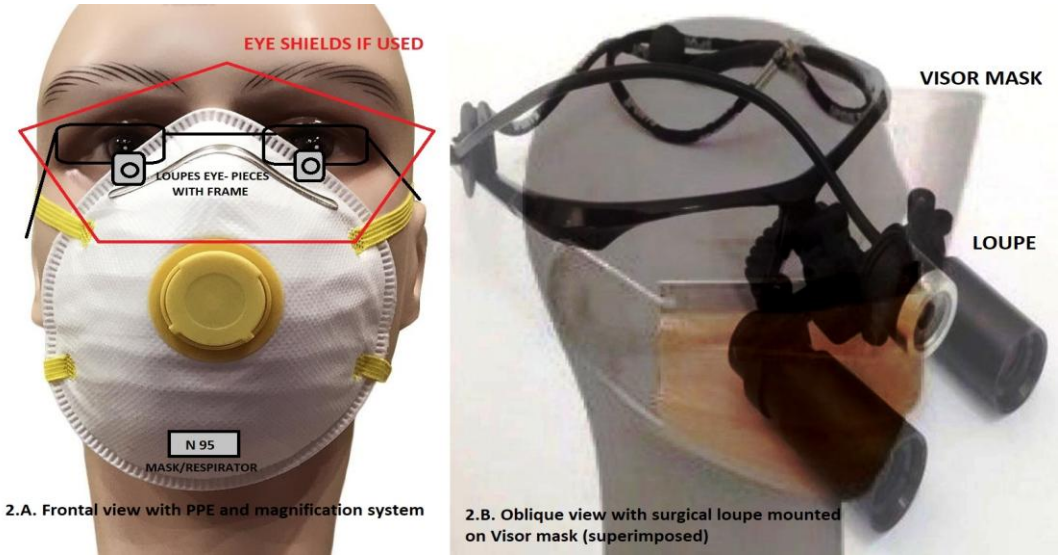


Figure 2: A and B- pictorial representation of using surgical loupes (spectacle mounted) with the N-95 mask or Visor mask

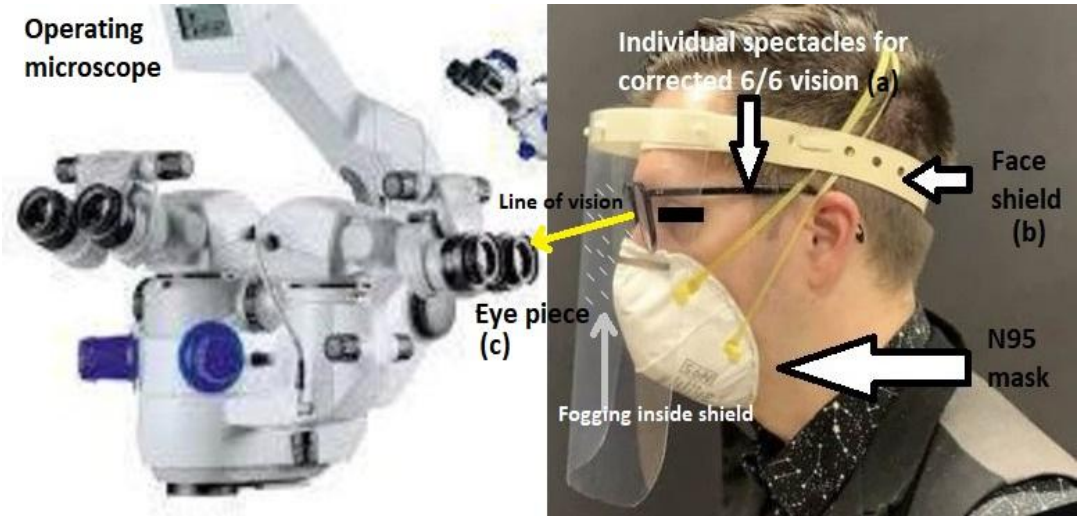


Figure 3: Superimposed and merged images depicting the use of face shield with operating microscope with different refractive media- (a)- user spectacles for corrected vision, (b)- face shield transparent plastic, (c)- microscope eye pieces, with fogging inside the shield as has been described.

5. Further Scope of Improvements

Having faced the difficulties in microsurgical procedures, we propose to device some modifications in the designs of PPEs for face and neck. FIG-4 depicts a simple way to tackle the problem of using optical magnification devices- the eye pieces of loupes or microscopes can be fitted into a specially designed partially foldable or malleable plastic shield with a horizontal slit in the middle which is lined with elastic bands (can be expanded or contracted partially to accommodate custom made loupe or microscope eye pieces as the inter-pupillary distances vary between users). It avoids introduction of a separate refractive medium in the magnification field but protects the face and eyes of the user at the same time like conventional face shields or Visor masks. It may minimise the building of fog on the inner surface of the shield as it is not connected with the upper edge of the mask as in cases of Visor masks. It can be designed in different sizes as well. A slightly more complicated design of a head mounted face shield being modified in the same way with a horizontal slit lined with elastic bands to accommodate the eye-pieces of loupes is depicted in FIG-5.B with 2 views- oblique and frontal. However the latter one might not be suitable for use with microscopes. Also such modified shields can be re-used after cleaning with standard disinfectants.

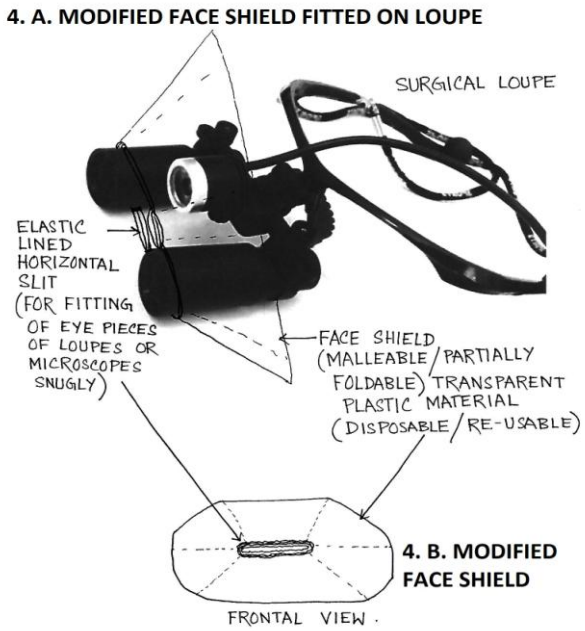
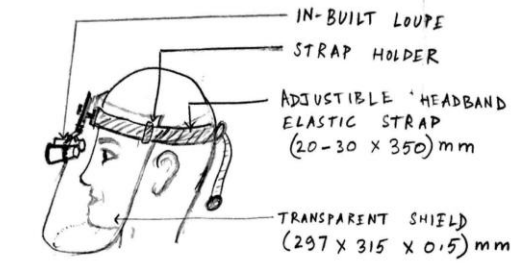
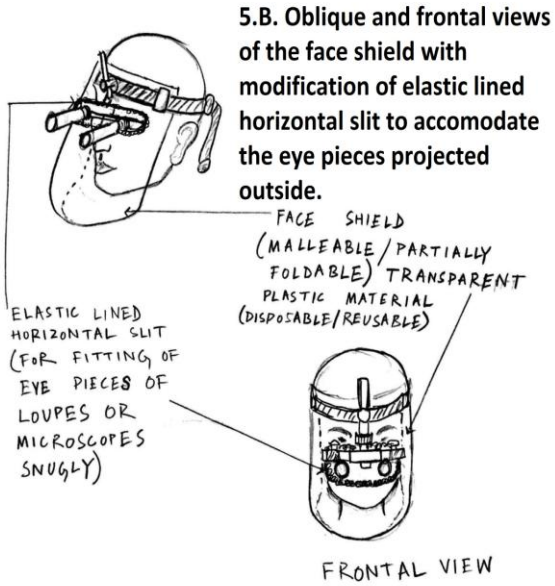


Figure 4: A and B- showing a modified plastic shield with a horizontal slit lined with elastic bands for accommodating the eye-pieces of magnification devices outside – 2 different views being shown.



5.A. Standard face shield with surgical loupe mounted on top of transparent shield surface.



5.B. Oblique and frontal views of the face shield with modification of elastic lined horizontal slit to accomodate the eye pieces projected outside.

Figure 5: A- Showing standard face shields (head bound) with loupes being mounted in front of the shield; B- showing a modified design with horizontal slit (lined with elastic band) to accommodate the eye pieces of the loupe outside.

6. Conclusion

Executing microsurgery with optical magnification using the standard PPEs amidst the COVID-19 era causes immense problems of vision. There should be a rational approach to modify designs of the protective face and neck equipments specifically for the microsurgeons.

7. Conflict of interest: none

8. Source of funding: none.

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