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Letter to the editor

3D printed transparent face mask for burn scars management: French experience

Dear Editor

Treatment of facial deep burns using a transparent face mask is currently the gold standard for preventing hypertrophic scars [1,2]. The transparent mask provides uniform compression that is adapted to the anatomical complexities of the face [3]. Transparent masks are also better accepted by patients than opaque, sometimes stigmatising, elastic hoods [4,5]. Transparency allows the clinical effectiveness of the mask to be verified, in connecting with the whitening of scars, through the thermoplastic material [6].

The mask manufacturing method was first published in the late 1970s and early 1980s [7,8]. The procedure begins by taking an impression of the area to be treated, using alginates or plaster strips which are applied to the face as soon as the epidermis has formed, to obtain a mould, also known as a negative. A positive is then cast in this mould, before the mask is plastically thermoformed onto the positive.

Since the 1990s [9], mask manufacturing techniques have evolved with the development of CAD/CAM (Computer-Aided Design and Manufacturing). Several teams have reported on their experience in using scanners [9,10] to take impressions, which have a number of advantages: no skin contact, rapid procedure to obtain a high-resolution 3D image, and patient comfort. Time to impression taking process is less than a minute. More recently, the use of tablets or smartphones with specific applications [13,14] has also been described, at optimised cost, with the aim of making the method even more widely available.

By taking digital impressions of the surfaces to be treated and using digital rectification software, it is possible to obtain a 3D image, which is then used in a variety of ways to manufacture the mask: 3D printing of a negative, using a powder sintering printer [12] or a wire deposition printer [14,15] to cast a plaster positive; 3D printing of a positive, using a powder sintering printer [16]; digital milling of a positive in polyurethane foam [9–11]; direct 3D printing of the face mask [17,18] to eliminate the need to manufacture the positive and speed up the procedure. In the latter case, Wei et al. [18] used a POLYJET 3D printer to print a transparent thermoplastic mask made from MED610®, biocompatible photopolymer material.

There are many issues involved in using these new technologies: compression efficiency, patient comfort and acceptability, manufacturing time, overall cost of the device including the cost of materials (scanning system, 3D printing equipment, thermoplastic used) and the cost of the medical and technical skills required. Mask manufacturing methods are still heterogeneous throughout the world, depending on the resources available [19].

Since 2010, our team has been manufacturing transparent masks after taking digital impressions of the face. After using a laser scanner (Fast scan - Rodin4D©) for the first few years, our team now manufactures transparent masks using the following procedure: taking a digital impression using a pulsed white light scanner (M4D scan - Rodin4D©) to obtain a 3D image, digital rectification of the 3D image using NEO® - Rodin4D© software with the addition of material to areas at risk of hypertrophy and removal of material from areas at risk of hyper-pressure, digital milling of the polyurethane foam positive from the file, thermoforming in a high-temperature oven of the ORLEN® mask on the polyurethane foam on which the therapist has previously marked out the contours of the future mask, the opening areas for the eyes, nostrils and mouth, and the positioning areas for the future rivets with five attachment points. The mask is then fitted with NEOPREN® straps.

We report our first experience of 3D printing of a transparent face mask, for a 37-year-old women suffering from thermal deep burns over 5 % of the total body surface, predominantly affecting the upper face. The patient had undergone surgical treatment: excision-grafting and artificial dermis (Matriderm®) of all lesions. On her arrival in rehabilitation, the scars assessment revealed a marked inflammatory state of the skin without hypertrophy and without major skin retraction. A full transparent face mask was prescribed in agreement with the patient, for hypertrophic scars prevention principally.

After obtaining the patient's written consent, two transparent ORLEN® pressure masks were manufactured using two separate procedures.

The patient received her first ORLEN® mask according to our usual manufacturing procedure described above. At the same time, the patient underwent a second M4D scan (Rodin4D©) with the aim of direct 3D printing of the mask in biocompatible transparent material. The 3D image was digitally rectified in the NEO® software as before. Additional digital rectification in the CUBE® software enabled the final mask to be cut out (mask contour, openings for the mouth, nostrils and eyes, location points for inserting the future five rivets). This file was sent to an external service provider for 3D printing. Printing was carried out on a STRATASYS© POLYJET printer, which polymerised the biocompatible MED610® photopolymer layer by layer until the final part was obtained. The printing time was 16 h. Once the mask had been printed, the rivets and straps were added and adjusted. The inside of the mask was further treated with isopropyl alcohol to give a smooth, shiny surface. Clinical assessment on fitting, facilitated by the transparency of the mask, showed effective compression with whitening of the grafted areas and no areas of hyper-pressure, similar to the first mask. The mask did not require silicone additions. Tolerance of the mask was satisfactory: comfortable mask, no reported pain, no hypersudation, no resurgence of itching.

The patient wore the two masks alternately, without any particular preference, until the end of scar maturation.

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We confirm the feasibility of the CAD/CAM manufacturing process for transparent masks for the treatment of facial burns, from digital impression taking to 3D printing of the appliance via digital grinding, in line with the results of the studies by Wei et al. [18]. In our case, there was no need for silicone additions.

The benefits of digital impression taking are well established, with multiple advantages for both patient and therapist [9,10]: precision, early impression taking, no skin contact, fast procedure, painless procedure with no induced stress, no need for premedication. Digital rectification allows shapes to be modified ad infinitum; there are countless tools available, not forgetting the possible development of pre-established rectification sequences available to teams depending on the locations to be treated, to optimise rectification time. As for 3D printing, subject to access to suitable printers, it can speed up the manufacturing process by dematerialising the positive. Its implementation calls on medical and technical skills for the manufacture of a device whose material must obviously be biocompatible, transparent to check its clinical effectiveness for the therapist, facilitate its acceptance by the patient, and smooth for optimal tolerance, such as MED610®, a polymer approved for permanent contact with the skin for more than 30 days, already used by the Wei team [18].

The exponential use in medicine of 3D printing of equipment and technical aids suggests that it could be developed in clinical practice for burn patients, subject to adequate resources and collaboration between care teams and technical teams within the framework of close partnerships [19].

Ethical approval

Written consent of the patient was obtained.

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None.

Credit Author Statement

In accordance with the requirements of BURNS, we, the authors of the article entitled ‘3D PRINTED TRANSPARENT FACE MASK FOR BURNS SCARS MANAGEMENT: FRENCH EXPERIENCE’, submitted for publication, submit the following statement detailing each author’s specific contributions to the research and writing of this article.

1. Dr Valérie CHAUVINEAU: Analysis of the results, Bibliography, Drafting of the manuscript.
2. Valérie JOLY: Data collection, Critical revision of the manuscript.
3. Emilie HARDY: Data collection, Manuscript revision.
4. Dr Marie-Noëlle BARTHOLOMEI: Study design, Data collection, Critical revision of the manuscript.

All authors made significant contributions to the conduct of this study and the writing of the article, and approved the final version of the manuscript. We confirm that each author made a substantial contribution to the study and that responsibilities are assigned fairly and equitably. No author has received funding for activities unrelated to the article, and we declare that there are no conflicts of interest related to the submission of this article.

Declaration

“During the preparation of this work, the author(s) used DeepL traduction in order to translate manuscript. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.”

Declaration of Competing Interest

None.

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