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DENTAL TECHNIQUE

Fabrication of a custom pediatric nasal mask for noninvasive ventilation using a maxillofacial elastomer: A straightforward technique

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ABSTRACT

The facial masks commercially available for noninvasive positive pressure ventilation therapy for children with clinical conditions of hypoventilation are limited by size and hardness. The present report describes a straightforward method of developing a nasal mask from a room-temperature vulcanizing silicone elastomer for daily contact with the nasal mucosa of babies during noninvasive positive pressure ventilation. The fabrication of the silicone mask with nasal tubes is based on maxillofacial prosthesis techniques, with retention with steel prongs and elastics. (J Prosthet Dent 2019;121:179-82)

Noninvasive positive pressure ventilation (NPPV) is used to provide ventilatory support in patients with acute ventilatory insufficiency.[1] Newborns and children who exhibit an uncommon breathing pattern for their age are usually treated with mechanical ventilation to optimize their gas exchanges and improve their clinical status.[2] NPPV provides additional physiologic benefits, including improved oxygenation, reduced ventilatory work, improved ventilation/perfusion ratio, reduced fatigue, and increased minute ventilation and residual functional capacity.[3,4] The various ventilatory modes of NPPV application have been based on commercially available facial masks or custom masks.[5-7]

The successful fabrication of a custom nasal mask involves correct moulage of the recipient area or the preparation of parts or models by rapid prototyping technology.[8,9] A colorless, soft, and biocompatible confection material with an epidermis-like texture[10,11] such as room-temperature vulcanizing (RTV) silicone is typically used. It can be joined with adhesives and to other silicones to guarantee outer sealing in the nasal region and effective therapy.[12-14] The recommendation is that custom nasal masks should be fabricated by an expert in the medical or dental field. Furthermore, the use of custom nasal masks has some advantages compared with commercially available facial masks, such as better adaptation to facial tissue with minimum detectable air escape. Thus, the use of a custom nasal mask should ensure effectiveness as well as patient comfort.[7]

The method described here uses the same material used for the fabrication of maxillofacial prostheses to obtain an effective pediatric custom mask for NPPV application. The silicone custom nasal mask fabrication technique described is straightforward and helps reproduce the facial contour and anatomy, ensuring excellent marginal adaptation to facial tissues.

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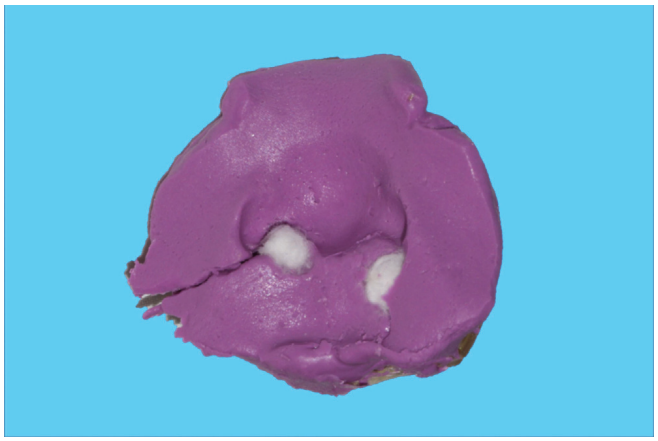

Figure 1. Impression mold of nasal region adapted to commercially available facial mask.

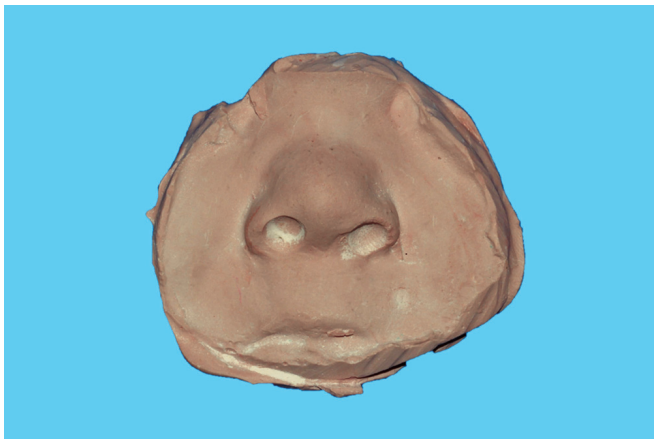

Figure 2. Plaster facial cast of nasal area.

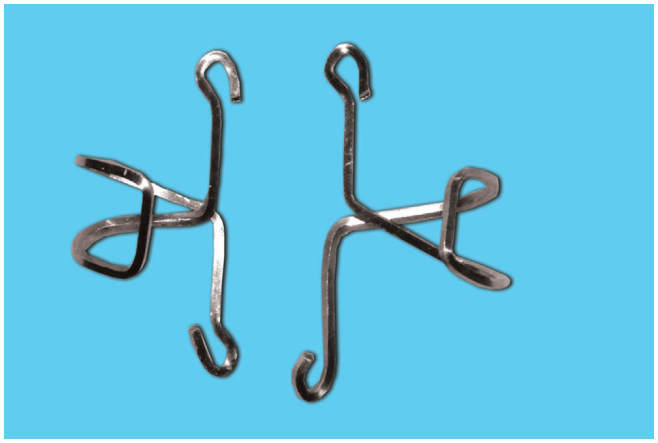

Figure 3. Hand-fabricated retention clips.

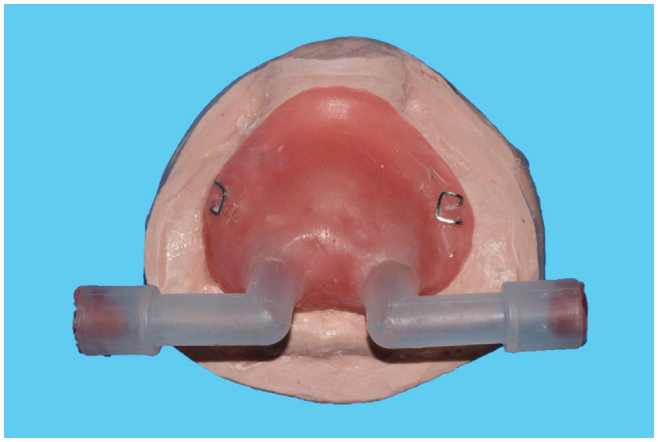

Figure 4. Custom pediatric nasal mask waxed and sculpted on face mold.

TECHNIQUE

1. Position the patient on his or her back and cover the fundus of the nasal cavity with cotton to avoid any airway risks during the facial moulage. Apply separating medium (Vaseline; Rioquimica) to the eyebrows to facilitate the removal of the impression material. Do not remove the nasal tube (mechanical ventilation) during the facial moulage for newborns, who are obligate nasal breathers for the first year. To maintain safe breathing, offer an oxygen supply by mouth and monitor vital signs and heart rate to assess patient status.
2. Cover the facial area by depositing small increments of irreversible hydrocolloid (Hydrogum 5; Zhermack) on the entire region below the eyebrows, the outer canthus of the eyes, and the oral lip tube. Adapt a previously cut-out commercially available facial mask (Nasal mask; ResMed) to the molding material, which will serve as a tray (Fig. 1).
3. Prepare a facial cast with plaster (Durone IV; Dentsply Sirona) and provide relief to the nasal wings with extrahard laboratory silicone (Zetalabor; Zhermack) before sculpting. Correct possible errors of position of the nasal tube in the mold before obtaining the plaster cast (Fig. 2).
4. Delineate the area of the facial mold to be wrapped with a wax pattern with a black cosmetic pencil (Hot Spot 10; Hot Spot Design) and adapt a double wax layer (Rose no. 7; Wilson, Polidental) to the entire marked area, reducing the thickness of the margins by about 0.5 mm throughout its extension.
5. Bend 2 hook-shaped retention prongs from square stainless steel orthodontic wire (Vareta Beta III-TiMo-.016″×016″; Morelli) to attach an elastic band with central perforations throughout its extension (Fig. 3).
6. Adapt a prepared retention prong and 2 prefabricated short nasal tubes (ResMed) to each lateral end of the wax pattern so that each one will fit into the entry to the nostrils, allowing breathing by positive pressure and connection to the ventilation device.

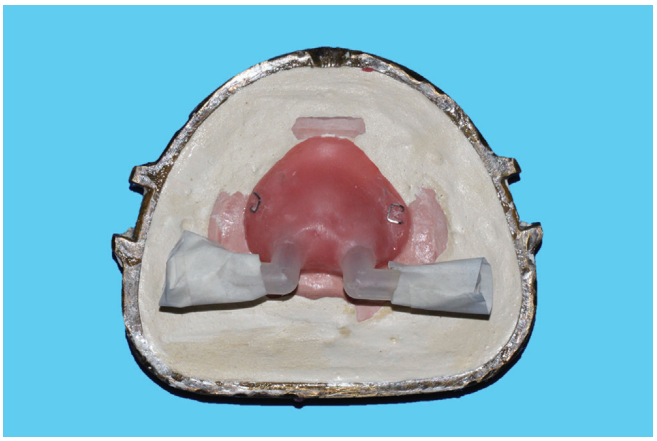

Figure 5. Inclusion of wax mold in metal dental flask.

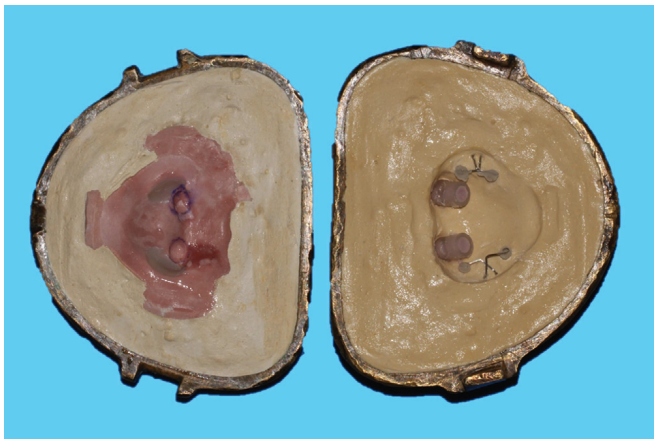

Figure 6. Flask ready for pressing and polymerization of room-temperature vulcanizing silicone.

Figure 7. Handling of room-temperature vulcanizing silicone in mold.

7. Insulate the end of the tube and include the ensemble (plaster cast and wax pattern) in a metal flask using plaster (Durone IV; Dentsply Sirona) (Figs. 4, 5). After the plaster has set, eliminate the wax pattern by boiling for 5 minutes, and open the muffle.
8. Manipulate the RTV silicone (A-2000; Factor II Inc) and insert it into the muffle, press, and wait for 72 hours for complete polymerization of the material (Figs. 6, 7).
9. Open the muffle, remove the silicone custom nasal mask, and perform the necessary cutting and adjustments. Cut small grooves on the outer surface of the nasal tubes and apply a minimum amount of medical silicone adhesive (A-564; Factor II Inc) to the interface between the maxillofacial silicone and nasal tubes to avoid air leakage. Disinfect the custom nasal mask for 10 minutes in 2.0% chlorhexidine solution (Maquira) and wash with distilled water.
10. Install the silicone custom nasal mask in the patient and adapt it by regulating the elastic band (Fig. 8) so that it will provide effective NPPV. Apply medical silicone adhesive or primers and RTV silicone to the outer third of the nasal tube near the nostrils to correct for any distortion of the bonding achieved between the RTV silicone and nasal tubes for long-term use. Consult the medical team, which must approve the silicone custom nasal mask before the application of NPPV therapy.

Figure 8. Installation of silicone custom pediatric nasal mask.

DISCUSSION

The different applications of the NPPV technique depend on the condition of the patient, who may actually be submitted to more than one technique depending on symptoms that improve or worsen.[3,5] More effective interfaces used for babies to promote continuous positive pressure in the nasal passages are attached to short binasal tips that fit into each nostril compared with a single and long nasal catheter.[4,5] In the present technique, the dynamic viscoelastic property of RTV silicone[7,10] permitted the nasal tube to remain in the position of entry to the nostrils with no air escape detected; further, it was easily adjusted with specific adhesives or primers, thus avoiding intubation of the patient. The application of the NPPV treatment proved to be an effective noninvasive resource that permitted increased residual functional capacity when associated with a silicone custom nasal mask. In addition, its flexibility and consistency, much like those of skin, provide comfort and adaptation, thus interrupting and preventing ulcerated dermal injuries.

A silicone custom nasal mask adapts perfectly to the anatomy of the patient and provides both comfort and efficacy, with minimum pressure on the supporting skin by using a light and durable material of a nontraumatic nature.[10] In addition, the silicone custom nasal mask should permit the air to enter the nose directly and be easily removed for cleaning; this should be performed with care to avoid skin irritation. In the patient illustrated, the fabricated silicone custom nasal mask fit the skin well, providing hermetic peripheral sealing.

The silicone custom nasal mask conformed to the standards described by Limeres et al,[7] who stated that the time spent to prepare a custom mask is compensated for by its durability and the few adjustments necessary. The RTV silicone used has a hardness of approximately 20 Shore A, which renders it similar to the texture of skin and helps reduce the thickness of the margins of the device.[10,11]

The basic components of the material are commercially available, and experience with prosthesis fabrication can be quickly acquired. Computer-aided design and computer-aided manufacturing techniques used in maxillofacial prosthetics represent an improvement in the fabrication of silicone custom nasal masks.[8,9] Obtaining a 3-dimensional model of the facial area by using a laser scanning system and the production of a plaster cast and/or a wax prototype by rapid prototyping are also straightforward and effective alternatives compared with conventional methods.[9]

Limitations of RTV silicone are usually related to color changes (which is not an issue with this application) and to the difficult adhesion to acrylic resin and implants.[12-14] Methods have been presented to improve the adhesion of RTV silicone to dental materials.[13,14] In the present technique, the use of a medical adhesive increased the adaptation of the nasal tubes to the silicone during the execution of NPPV. In addition, the fabrication process may become expensive because of the RTV silicone.

SUMMARY

This article describes a technique used to fabricate a silicone custom nasal mask that was appropriate in terms of hardness and marginal thickness and that was biocompatible with extraoral tissues. The laboratory procedure is straightforward and easy to handle, with a satisfactory cost/benefit ratio. The silicone custom nasal mask is well accepted by babies during NPPV therapy, with consequent advantages compared with a commercially available facial mask.

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