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| Author (Year) | Training Model | Construction of the Model | Palatoplasty Skills | Reusability | Cost | Fidelity | Evidence of Improved Outcomes | Rating of Anatomical Fidelity and Realism |
| Plana et al., 2018 | 3-dimensional computer-based simulation | 3-dimensional digital animations were developed for the pathologic anatomy, surgical markings, and critical steps of selected cardinal cleft procedures. | Model has surgeries available for Mohler unilateral cleft lip retrograde bilateral cleft lip, radical intravelar veloplasty, Furlow double-opposingZ-plasty, pharyngeal flap, and Dibbell/Tajima cleft rhinoplasty. | Yes | Freely available on Internet browsers and mobile application platforms. | Anatomical and tissue validity not reported. | Not reported. | III |
| Cote et al., 2018 | 3-dimensional printed haptic simulation model | 3D printed hard palate made with polylactic acid filament deposit. Soft palate, mucosa, tensor veli palatini, levator veli palatini, palatoglossus, palatopharyngeus moulded using silicon elastomer of 2.5 mm, attached to hard palate with glue, and covered with elastomer. Piece of rubber band used to model the neurovascular bundle exiting the greater palatine foramen. | Model is appropriate for teaching conceptual aspects of palatoplasty but is not suitable for teaching all surgical skills. von Langenbeck palatoplasty is demonstrated on this model in this study. | No | $7.31 USD | Of twelve physicians, majority reported that model anatomy and tissues were similar to human anatomy and tissue. Lack of human properties such as bleeding. | Resident trainees were used to validate the model. They showed improvement in surgical skills following use of model. | I |
| Podolsky et al., 2017 | 3-dimensional simulation model | Cleft palate simulator was based on a noncleft, 22-month-old computed tomographic scan which underwent further computer modelling. Simulator is composed of a modelled cleft of the secondary palate, cranial base, detailed musculature, and soft-tissue layers. Simulator consists of an oral cavity base with a cartridge containing the palate angled to represent the typical palatal angle when patient’s neck is extended during cleft repair. | von Langenbeck palatoplasty is demonstrated on this model in this study. Authors propose that any type of palate repair for a complete cleft of the secondary palate can be performed on the simulator. | Yes, with replacement of the cartridge. | Not reported. | Of fifteen physicians, 85% agreed that the simulator is anatomically accurate and realistic. | 19 physicians used the simulator to perform a von Langenbeck palatoplasty and completed pre-test and post-test multiple choice questionnaire on cleft palate anatomy and repair. Average test scores improved by 52.27% following simulator use. | I |
| Pinho et al., 2016 | 3-dimensional synthetic bench model | Maxillary dental cast taken and 2-mm thick plates of ethylene vinyl acetate simulating the oral and muscle layers were inserted on the posterior edge of the hard palate to mimic abnormal insertions of the cleft levator. Drinking straw sandwiched between oral and muscle layers to simulate greater palatine vessels. A 2-mm thick plate of ethylene vinyl acetate simulating the nasal layer was glued onto the hard palate of the dental cast and the oral/muscle component was mounted onto nasal layer using adhesive tape. A plastic water cup lined with black fabric was used to simulate the oral cavity of a 12-month-old patient. The dental cast model was fixed into the water cup using adhesive tape. | Model was designed to teach 2-flap palatoplasty, V-Y pushback palatoplasty, and double-opposing Z-palatoplasty. Model is intended to teach the following cleft repair skills: operating in a small cavity, poor depth perception, awkward angles, limited access, poor visualization, fragile soft tissue handling, small flaps, in-depth suturing, simultaneous access by the trainee and faculty, and the use of an operating microscope. | Yes, with replacement of ethylene vinyl acetate plates. | Not reported but authors state model is inexpensive. | Authors propose that use of a life-sized maxillary dental cast preserves important anatomical reference points and that the ethylene vinyl acetate plates reliably mimic the fragility of soft palate tissues. Authors suggest that model lacks fidelity with actual surgical practice. | Not reported. | II |
| Rau et al., 2015 | 3-dimensional haptic anatomical model | A polyvinyl chloride-based plastic anatomical baby doll was purchased from an anatomic model company. A complete unilateral cleft lip/palate was marked onto the lip, subnasal region, and palate based on a patient plaster model. A scalpel or soldering iron was used to cut out the marked areas and the edges were rounded off using a handheld rotating milling machine. A round slice of plastic the size of a €2 coin was cut from the thigh and melded onto the cleft side ala of the nose, simulating the typical flattened nose wing. The doll’s hard and soft palate were milled out and a patient cast of a cleft palate was fixated into the doll’s mouth using an iron rod. Skin coloured lacquer was used to adapt the skin colour. | Model is designed to teach taking intraoral impression and fixating drinking and nasoalveolar plates. | Yes | €200 | Model materials are rigid and do not simulate physiologic oral movements. | 138 students were taught using the model and completed pre-test and post-test multiple choice questionnaires. 69.9% showed an improvement in their knowledge. | II |
| Liu et al., 2014 | 3-dimensional paper model | 3” x 3” sticky notes of two different colours are used, one to simulate the oral and nasal mucosa and one to simulate the palatal muscle and submucosal tissue. An outline of a palate shape is drawn on the mucosal layer and three layers are cut. Incisions of the Z-plasty are made using scissors, scalpel, or exacto-knife and flaps are elevated. Clear tape is used as sutures. | Model is designed to simulate the Furlow palatoplasty technique. | No | Not reported but authors state model is inexpensive. | Authors report the model to be rigid, thus not accurately reflecting the actual lengthening of the mucosa and muscle. | Not reported. | III |
| Senturk, 2013 | 3-dimensional sponge and plastic model | 12 x 5 cm sponge cut, doubled, and stabilized with staples. 5 x 1 cm piece removed from middle, then sponge stapled into a plastic water bottle. Plastic water bottle fixed onto table with adhesive plaster | Model is designed to teach suturing at depth, familiarization with working in a small and narrow cavity, and making incisions. | Yes, with replacement of sponge. | Not reported but author states model is inexpensive. | Anatomical and tissue validity not reported. | Not reported. | III |
| Nagy et al., 2009 | 3-dimensional plaster and latex model | Alginate impression material used to take impression of a 1-year-old patient with cleft palate. Plaster model of oral cavity is made from impression and halved horizontally at the level of the parotid papilla. Alginate impression of the palatal part is taken and ground 4mm deep and double layered with a magenta rubber dam to simulate the double mucosal lining of the soft palate. Model is cut at the junction of soft and hard palate. Triangular pieces of red ink pad attached to posterior oral part of plaster hard palate to simulate muscle layer of soft palate. An artificial mucosal lining is cut from latex exam gloves and fixed over the hard palate muscle layer. A balloon is filled with sand to simulate the tongue and glued to the inner surface of a plastic water cup. Palatal model is glued into the cup opposite to the tongue model. Cup is covered with a rubber dam and an oval opening is cut to simulate the oral orifice. All component measurements based on those obtained from 1-year-old patient with cleft palate. | Model is designed to simulate the Furlow palatoplasty technique. | No | Not reported but authors state model is inexpensive. | Authors propose that texture of model simulates the fragility of cleft palate tissues. | Not reported. | II |
| Vadodaria et al., 2007 | 3-dimension plastic, latex, and foam model. | Hollow plastic ball used to simulate a 6-month-old infant mouth. Hard palate was simulated using a slightly conical plastic surgical measuring jug. Oral and nasal layers of soft palate were simulated using latex; muscle layer made of dense red foam. The soft palate component was mounted onto posterior edge of hard palate using Superglue. Latex was found to be difficult to incise with a scalpel; hence, it was preincised and closed with a Sellotape material. A high-density plastic mug was used as a mouth holder and fixed to a table top with a G clamp. Latex webbing used on the inner margin of the plastic mug to prevent glare from microscope. | Model is designed to train junior surgeons in microscope discipline, working in a small and narrow cavity, making incisions on the cleft edge, dissecting layers in awkward angles, and suturing at depth. | Not reported. | Not reported. | Authors suggest that model lacks ability to teach skills of delicate dissection of mucoperiosteum and nasal lining from hard palate and velar muscles from oral and nasal linings. | Not reported. | III |
| Pappachan et al., 2005 | 3-dimensional latex and sponge model | A palatal arch is cut from a rubber dam and a surgical glove; the cut pieces are punched with holes corresponding to teeth in the maxillary arch form. A piece of sponge is cut into a palatal arch, simulating the muscle layer, and stuck between the two pieces. On a phantom head with typodont teeth fixed, the sheets are pulled over their corresponding teeth with the gloves sheet deep to the rubber dam sheet. The phantom head is mounted over a table top and Dingman’s retractor is applied. | Model is designed to simulate muscle dissection and vertical mattress suturing. | Yes, with replacement of palatal component. | Not reported. | Anatomical and tissue validity not reported. | Not reported. | III |
| Schendel et al., 2005 | Computer simulation model with haptic feedback | 11-day-old male patient with complete left unilateral cleft lip, alveolus, and palate was scanned with CT. CT scan was used to generate a 3-dimensional computer model of bone and soft tissue. A haptic stylus is used as a virtual cutting tool and generates force-feedback to the user. | Any of the major procedures for cleft repair can be performed. | Yes | Not reported. | Anatomical and tissue validity not reported. | Untrained laypeople and plastic surgery residents were used to validate the model. Residents scored higher than laypeople on all trials. Both groups scored higher, had increased accuracy, and decreased speed as they performed more trials. | III |
| Matthews, 1999 | 3-dimensional cardboard model | Hard palate is modelled by cardboard or Styrofoam sheet cut into a 3-inch square. 1-inch wedge is cut into one side, simulating a cleft. Soft palate modelled by 3x8 inch latex with muscle fibres drawn on. Latex is folded in half and stapled onto cardboard frame. Staples are placed in an arch pattern to simulate the alveolar arch. | Model is designed to simulate the Furlow palatoplasty technique by showing positions of incisions and directions of muscle fibres. Surgical incisions are made using scissors. | Numerous demonstrations possible until latex tears. | Not reported by authors state model is inexpensive. | Anatomical and tissue validity not reported. | Not reported. | III |

Table 1: Key features of twelve models of cleft palate described in the literature.