Initial experience of high-fidelity 3D-printed models for training in septorhinoplasty

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Dear Editor:
Gaining the confidence needed for independent practice in septorhinoplasty remains a difficulty for surgeons in training [(1)]. Surgical "craft" courses have long been a way for surgeons to bolster and improve their skills under direct instruction in a safe environment. Technological advancements have led to the development and growing popularity of non-cadaveric septorhinoplasty training courses [(2)].

This study aimed to evaluate the utility of a high-fidelity 3D-printed model for septorhinoplasty training, produced by Fusetec Ltd. (Adelaide, Australia). The composite materials used in their construction are designed to mimic mucosa, cartilage and bone. Each training model fits within a mannequin head holder and is replaced like a cassette (Figures S1 and S2).

Nine participants were recruited, all of whom were fellowship-trained surgeons maintaining a rhinoplasty practice. Participants were provided with a Fusetec septorhinoplasty training cassette and each asked to undertake a variety of procedures including septal surgery, dorsal hump reduction, osteotomy, spreader grafts, dorsal augmentation and nasal tip work (specifics listed in full in Supplementary materials). All participants completed a purpose-adapted feedback survey to explore both the face and content validity of this surgical trainer [(3)].

When reviewing both domain and sub scale averages (Table 1), opinions were mixed which is expected given this model remains in development and has yet to be brought to market as a commercial product. The majority (78%) of participants believed that the model was able to mimic nasal anatomy and was of high fidelity. Indeed, the models were also adjudged by most participants to be realistic representations of nasal anatomy and the bony tissues, in particular, seemed to garner positive feedback. More neutral responses were obtained to statements regarding the haptic feedback provided by the model to the surgeon, particularly in relation to handling of cartilage tissue.

Most participants agreed that the models were useful for learning nasal anatomy and in surgical planning. Responses were more measured concerning the performance of the model for simulating specific surgical techniques. There was complete agreement that the models helped develop fundamentals in nasal osteotomy and a majority felt that they were also useful for both reduction and augmentation of the dorsum. Opinions were more varied on the content validity of the models for cartilaginous work with surgeons less convinced regarding haptic feedback and, accordingly, the strength of the model for teaching techniques such as grafting or surgery of the septum or nasal tip. Difficulties reported included the frequency with which sutures 'cheesewired' through cartilage (see postoperative images in Supplementary materials) and likely reflect the relative weakness of the current model's representation of cartilage.

Results are limited by the pilot nature of this study, which precluded statistical analysis and would be improved upon by future studies, with a larger and more diverse participant group. Recent work by another group (including members who were involved in the model design) [(4)], reviewing the performance of the same model, did not report such specific concerns over the model's simulation of cartilage, though it is noted that there is ongoing development work in progress and we hope the results of this study help further inform this.

Cadaveric training is not without its own limitations and neither fresh-frozen nor embalmed specimens handle in the same way as in the operating theatre. Customisable trainers allow for predetermined specifications to be made in terms of nasal anatomy and courses utilising a 3D-printed trainer can standar-

Table 1. Summary results from study participants.

			Strongly disagree 1	Disagree 2	Neutral 3	Agree 4	Strongly agree 5	Mean rating score	SD
Face validity	1	Appearance of anatomical structures is realistic	-	-	2 (22%)	7 (78%)	-	3.78	0.44
	2	The cartilage tissue feels realistic	-	2 (22%)	5 (56%)	2 (22%)	-	3.00	0.71
	3	The bony tissue feels realistic	-	1 (11%)	1 (11%)	7 (78%)	-	3.67	0.71
	4	Instrument application is realistic	-	1 (11%)	5 (56%)	3 (33%)	-	3.22	0.67
	5	Tactile/haptic feedback is realistic	-	1 (11%)	5 (56%)	3 (33%)	-	3.22	0.67
Global content validity	6	This model is able to mimic actual nasal anatomy (high fidelity)	-	-	1 (11%)	8 (89%)	-	3.89	0.33
	7	This model is useful for learning nasal anatomy	-	-	1 (11%)	5 (56%)	3 (33%)	4.22	0.67
	8	This model is useful for learning surgical planning for rhinoplasty	-	1 (11%)	2 (22%)	4 (44%)	2 (22%)	3.78	0.97
	9	This model is useful for improving my operative techniques	-	1 (11%)	1 (11%)	6 (67%)	1 (11%)	3.78	0.83
	10	This model helps develop my hand-eye coordination needed for septorhinoplasty surgery	-	2 (22%)	-	6 (67%)	1 (11%)	3.67	1.00
	11	This model is useful as an overall training tool	-	1 (11%)	2 (22%)	4 (44%)	2 (22%)	3.78	0.97
	12	This model is an adequate training platform for future surgeons	-	1 (11%)	3 (33%)	4 (44%)	1 (11%)	3.56	0.88
Task specific content validity	13	This model correlates with the essential skills needed for septorhinoplasty	-	-	3 (33%)	5 (56%)	1 (11%)	3.78	0.67
	14	This model helps develop dexterity, accuracy, and precision with instruments	-	1 (11%)	5 (56%)	3 (33%)	-	3.22	0.67
	15	This model helps to develop fundamentals involved in septal surgery	-	2 (22%)	4 (44%)	3 (33%)	-	3.11	0.78
	16	This model helps to develop fundamentals involved in dorsal hump reduction	-	-	3 (33%)	6 (67%)	-	3.67	0.50
	17	This model helps to develop fundamentals involved in nasal osteotomies	-	-	-	9 (100%)	-	4.00	0.00
	18	This model helps to develop fundamentals involved in placement of spreader grafts	-	-	5 (56%)	4 (44%)	-	3.44	0.53
	19	This model helps to develop fundamentals involved in suturing and nasal tip surgery	1 (11%)	3 (33%)	-	5 (56%)	-	3.00	1.22
	20	This model helps to develop fundamentals involved in dorsal augmentation	-	-	3 (33%)	6 (67%)	-	3.67	0.50
Validity domain scores	-	Face validity mean sore *(items 1-6)*	3.51	0.36					
	-	Global content validity *(items 7-12)*	3.80	0.23					
	-	Task specific content validity *(items 13-20)*	3.49	0.35					
	-	Overall mean score *(items 1-20)*	3.57	0.34					

dise curricula with delegates and faculty all essentially working from the same consistent nose [5,6]. Results from this study suggest this would bring utility in understanding anatomy, surgical planning and in learning osteotomy and dorsal reduction and augmentation.

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Authorship contribution

SPW and SCL designed the work, acquired and analysed the data, drafted, revised and approved the manuscript; SPW and SCL agree to be accountable for all aspects of the work.

Conflict of interest

The authors (SPW and SCL) have no conflicts of interest to declare which are relevant to this study.

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This manuscript contains online supplementary material

SUPPLEMENTARY MATERIAL

Materials and methods

The training model

The life-size 3-D printed models are made by Fusetec Ltd. (Adelaide, Australia). The composite materials used in the construction of these models are designed to mimic mucosa, cartilage and bone. Each training model fits securely within a mannequin head holder and can be replaced like a cassette (Figure S1). There are currently three models, each with a different septal deviation, dorsal hump and nasal tip configuration. The current models do not have a covering layer of skin.

Ethics approval

Human ethics committee approval was not required for this study. All participants volunteered to evaluate the training models and agreed provide feedback.

Surgical techniques used by participants

Septoplasty
Dorsal hump reduction
Osteotomy (with osteotomes or with Piezo device)
Spreader grafting
Septal extension graft
Septal batten graft
Columella strut
Crura steal
Tip suturing including tongue-in-groove
All suturing performed with 5-0 PDS II (Polydioxanone, Ethicon Inc., Johnson & Johnson).

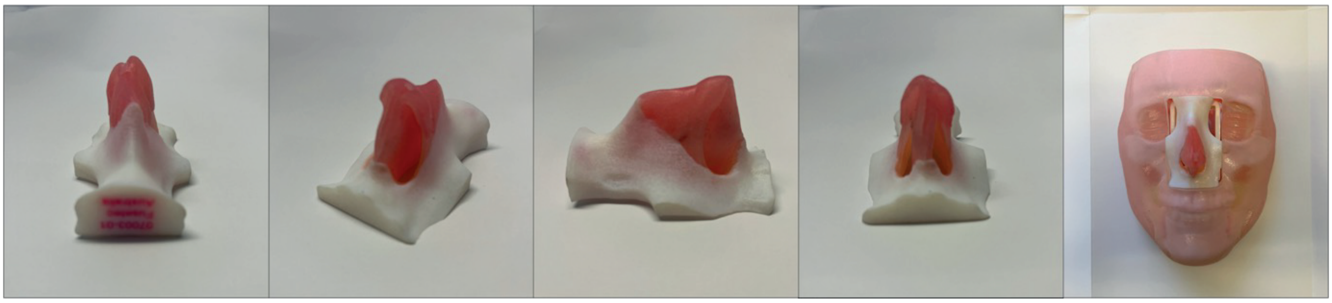

Figure S1. Composite image, depicting a variant of the septorhinoplasty training cassette. Notably, pane (a) shows asymmetric nasal tip, pane (b) a composite bony and cartilaginous dorsal hump and pane (d) septal deviation. Pane (e) demonstrates the cassette when housed within the mannequin head holder.

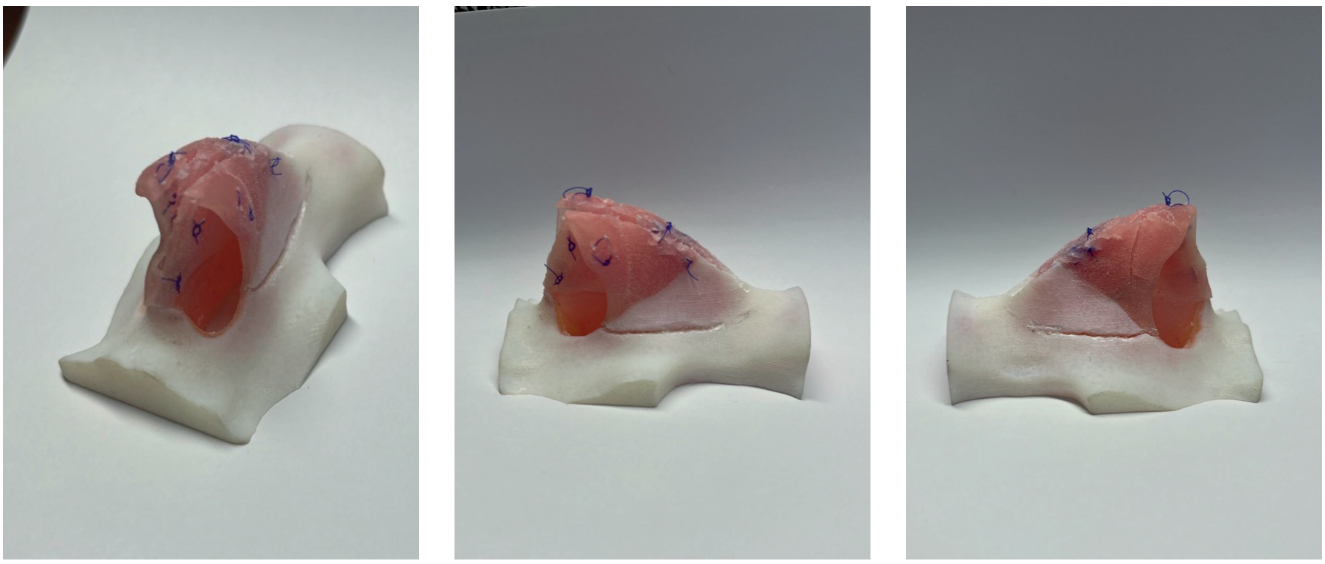

Figure S2. Composite image, depicting a septorhinoplasty training cassette after use in the study by one of the participants. Notably, pane (a) shows "cheesewiring" of 5-0 PDS II suture placed in dome.