EuroSOMT SCHOOL OF MODERN TECHNOLOGY

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Preliminary results of EuroSOMT Erasmus+ Higher Education Partnership project : Comparison of the 3D printing data of male and female pelvic models

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ABSTRACT

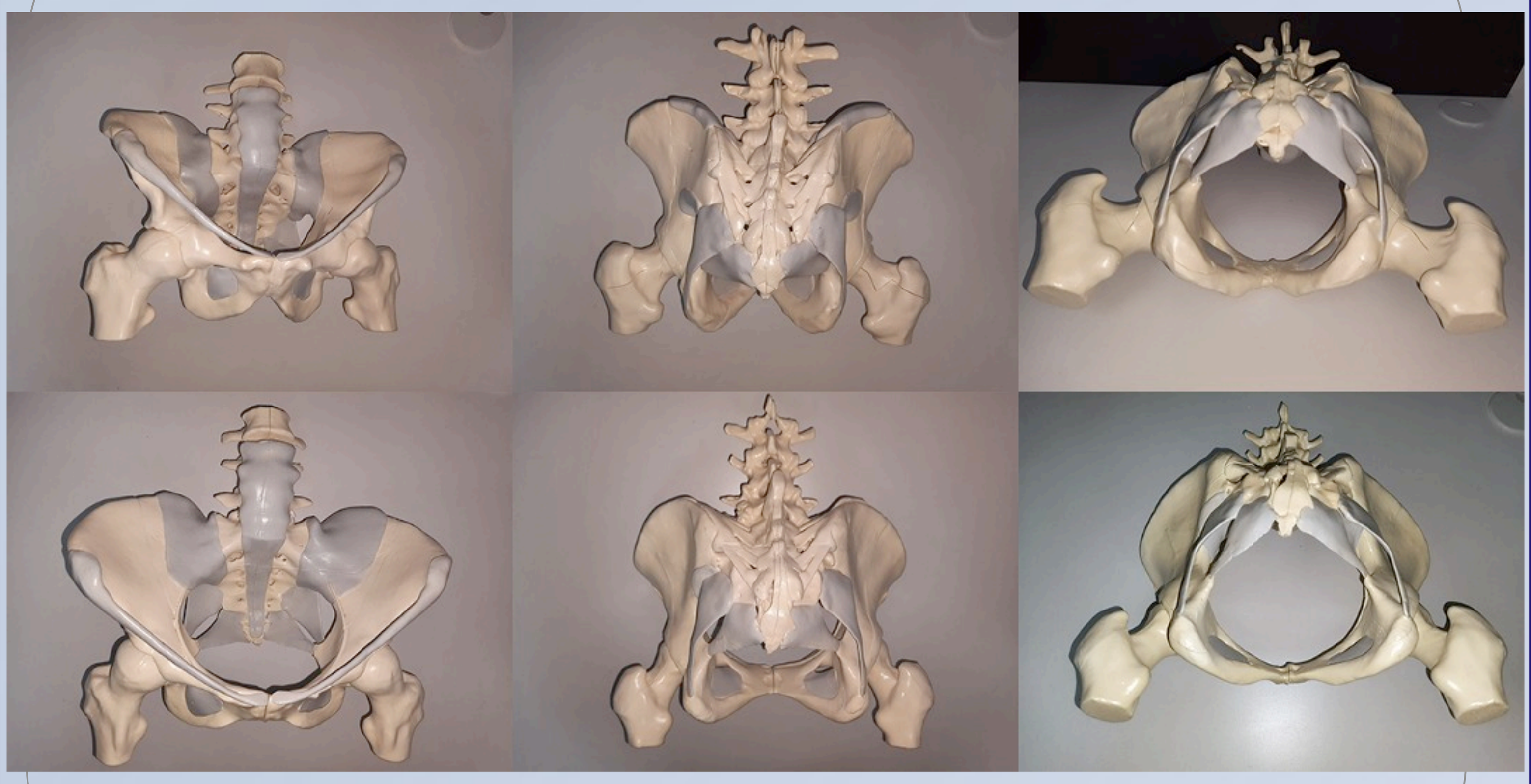
A lack of standardized training curriculum and appropriate simulators in functional urological and uro-gynecological surgery is a fact. Possible reasons of this limitation are increasing complexity in surgeries with complex pelvic anatomy, high cost in simulators on market, lack of standardized training curriculum neither during residency and fellowship period, simulation-based standard fundamental functional urological surgery training modules. EuroSOMT ERASMUS+ project aimed to create simulators which are produced with using 3D printing and virtual reality technology via consensus of project outcomes and experts' view from EuroSOMT Working Group of ICS Institute School of Modern Technology, ICS Standardization Committee. In this study, we presented the first preliminary results of male / female 3Dprinted physical simulators in terms of technical properties, we compared the details of the printing processes of 3D physical simulators to be used in the training of sling surgeries in female and male.

METHODS

The steps of preparation of simulation-based training modules and curriculum in the scope of EuroSOMT project are; production of patient-specific CT-reconstructed 3D printed models with using patient/cadaver radiologic data, creation of VR/AR models with using the same 3D modeling scans, establishment appropriate syllabus and preparation evaluation documents, assessment of skills (technical and cognitive) in learning-training and teaching activities (3 times in a year), preparation of e-learning videos. We determined totally 17 surgical procedures (10 female, 7 male), enrolled to the curriculum for preparation procedure-based simulators. For each procedure, standard steps were determined in the curriculum. 3D printing technology was used for physical, virtual reality technology was used for non-physical simulators. All anatomical models will be provided by real-patient CT or MRI radiologic images, 3D reconstructed with using Mimics software and 3-matic.

We used following steps for the reconstruction and 3D printing of the customized anatomical models. First the extraction of CT or MRI data, from patients or cadavers, with a medical imaging device and generating the DICOM files from them with MIMICS software, secondly masking the area of interest and extracting the .STL files of the 3D models with MIMICS and 3D surface rendering, and texturing for the realistic human and surgery tool model with 3DS MAX and Z-Brush and finally printing them with FormLabs2 3D printer. We used white and elastic resin for skeleton and soft tissue and organs respectively (1,2). For 3D printing process, we used streolithography method in which laser printing modality used. The 3D printer brand was FormLabs 2 Bio.

Figure2: Anterior, posterior and inferior(perineal) aspect of the male (upper row) and female(lower row) pelvic models respectively



RESULTS

Production time, resin type and quantities of 3D printed male and female physical simulators are shown in Figure 1. Anterior, posterior and inferior(perineal) aspect of the male (upper row) and female(lower row) pelvic models can be seen respectively in Figure2.

Approximately the same time (300 hours) was spent for models of both male and female. Since the skeleton of the male model was larger, approximately 1.5 times more white resin was used. It is more difficult to segment and model the soft tissues and organs (eg. vagina) of the female model from radiological images and also print it successfully. However, before 3D printing, for each model, we determined exact anatomic structures which were important for male and female functional urologic surgeries. With this regard, we decided to make 3D modeling and segmentation in terms of bone, muscle, ligaments and organs. Following the separate production of the structures, post-process period was achieved to implement the anatomic models to physical surgical simulators. However, the models were prepared as a useful properties to do endoscopic examination and surgery as well.

Figure1: Production time, resin type and quantities of 3D printed male and female physical simulators.

Female Pelvic Model

Name Of The Part	Production Time in Printer	Type Of The Resin	Amount Of Resin(mL)	Print Status
female pelvic bone right 1	18 hours	White V4	150	Failure
female pelvic bone right 1	17 hours and 56 minutes	White V4	142	Success
female pelvic bone right 2	14 hours and 44 minutes	White V4	93	Success
female pelvic bone right 3	13 hours and 18 minutes	White V4	89	Success
female pelvic bone right 4	14 hours and 11 minutes	White V4	108	Success
female pelvic bone left 1	21 hours and 38 minutes	White V4	179	Success
female pelvic bone left 2	17 hours and 36 minutes	White V4	119	Success
female pelvic bone left 3	12 hours and 50 minutes	White V4	96	Success
female pelvic bone left 4	11 hours and 32 minutes	White V4	87	Success
Female Bladder	21 hours and 8 minutes	Elastic 50A V1	143	Success
Female Rectum	14 hours and 46 minutes	Elastic 50A V1	51	Success
Uterus	23 hours and 14 minutes	Elastic 50A V1	137	Failure
Uterus	20 hours and 56 minutes	Elastic 50A V1	123	Failure
Vagina	13 hours and 35 minutes	Elastic 50A V1	101	Success
Uterus	39 hours	Elastic 50A V1	110	Success
Female Rectum-reprint	17 hours and 21 minutes	Elastic 50A V1	51	Success
	Total Hour: 289 hour	Total White Resin:	1063 ml	
		Total Elastic Resin:	716 ml	

Male Pelvic Model

Name Of The Part	Production Time in Printer	Type Of The Resin	Amount Of Resin(mL)	Print Status		Muscles
male pelvic bone left 1	18 hours	White V4	170	Failure		Anal Sphincter
male pelvic bone left 1	18 hours and 36 minutes	White V4	172	Success		Bulbospongiosus
male pelvic bone left 2	22 hours and 33 minutes	White V4	192	Success		Coccygeus Muscle
male pelvic bone left 3	21 hours and 4 minutes	White V4	168	Success		Deep Transverse Perineal Muscle
male pelvic bone left4	15 hours and 44 minutes	White V4	121	Success		Illiococcygeus Muscle
male pelvic bone right 1	20 hours and 54 minutes	White V4	188	Success		Ischiocavernosus Muscle
male pelvic bone right 2	20 hours and 11 minutes	White V4	165	Success		Obturator Internus
male pelvic bone right 3	23 hours and 24 minutes	White V4	151	Success		Priformis Muscle
male pelvic bone right 4	16 hours and 18 minutes	White V4	132	Success		Pubococcygeus Muscle
Bulbospongiosus Muscle	6 hours and 53 minutes	Elastic 50A V1	21	Success		Puborectalis Muscle
Male Bladder	19 hours	Elastic 50A V1	154	Success		Superficial Transverse Perineal Muscle
Prostate	14 hours and 40 minutes	Elastic 50A V1	71	Success		
Penis	19 hours and 45 minutes	Elastic 50A V1	73	Success		
Rectum Male	33 hours	Elastic 50A V1	154	Success		
Bulbospongiosus Revised	6 hours and 53 minutes	Elastic 50A V1	21	Success		
Bulbospongiosus Revised 2	4 hours and 51 minutes	Elastic 50A V1	21	Success		
Male artery	13 hours and 27 minutes	White V4	77	Success		
Male vein	14 hours and 32 minutes	White V4	98	Success		
	Total Hour: 306 hour	Total Elastic Resin:	515 ml			
		Total White Resin:	1634 ml			

CONCLUSIONS

If a personalized model is to be produced in functional urology, the beginning processes should be made in this way and the type and amount of material should be determined by considering the anatomical differences between male and female.

3D printhed models are useful and promiding modality for teaching process for residents and young urologists in terms of complexity of functional urologic surgeries.

Anatomic comparison shoud be take into account between male and female 3D printed models before start creation the physical simulator.

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