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Analysis of soft tissue materials for simulation development

J. Caldwell MD, J. Mooney MD
Milton S. Hershey Medical Center

PennState Health Milton S. Hershey Medical Center

PennState Health Children's Hospital

Abstract

Creation of simulants by a simulation center is a well established method of meeting unique simulation needs as well as stretching available budgets. 3D printing has been identified as a potential tool for creation of these simulants. However, limitations of current 3D printing materials (being generally rigid) calls for combining these techniques with other techniques such as casting and molding. The material properties of 3D printed objects were studied previously, and this project was developed to begin examining the properties of available casting materials that may be useful.

Objectives

1. Examine commonly available materials utilizing CT imaging.
2. Examine commonly available materials utilizing CT imaging.
3. Examine the physical resistance to needle passage in commonly available materials.

Methods

Material samples for a range of silicone and urethane materials from commercial suppliers in the United States. Additionally, food grade gelatin and commercially available ballistic getaline were obtained from US sources. Materials were obtained from Smooth-on (smooth-on.com), TAP Plastics (tapplastics.com), Poly-Tek Development Corp. (polytek.com), Clear Ballistics LLC (clearballistics.com) and Knox Gelatine (knoxgelatine.com). For casting the liquid/gel compounds, forms were created from acrylic sheet using a laser cutter. IN cases of viscous compounds, materials were vacuum degassed prior to pouring and curing. Additional forms for casting foam materials were created and assembled using M3 screws/nuts. These forms allowed for expansion of the foams to a uniform size with excess material escaping via the opening for pouring the material in.

All materials were placed on a wooden (MDF) frame, separated by acrylic sheet squares. This frame with material samples scanned in a hospital CT scanner (Siemens 128 Slice Flash Scanner, 5mm slices reconstructed down to 3mm by 3mm). After CT imaging, material slices were imaged under ultrasound (SonoSite X-Porte, 15-6MHz probe, MSK mode, US gel to cover probe head before probe placement). Each slice was imaged with contrast at minimums setting, maximal setting and then 'auto' contrast.

For analysis of needle penetration force, a specialized rig was developed and built by one of the authors (Image 1). This assembly allowed 18ga needles (2" Touhy epidural needles, Havel's Incorporated, Cincinnati, OH) and 22ga needles (1.5" Quincke type point spinal needle, BD, Franklin Lakes, NJ) to be driven into the materials at a controlled rate (7mm/sec) while measuring the force using a calibrated force gauge (Model M3-5, Mark-10 Corporation, Copiague, NY). Data from the force gauge was transmitted via USB to the Mesur-Lite Software (Mark-10 Corporation, Copiague, NY) and exported to Excel (Microsoft, Bellevue, WA). Force testing was repeated 4 times for each sample and needle, with the results averaged.

Results

Select CT imaging results are displayed in Images 1 through 6. Select ultrasound imaging results are displayed in Images 7 through 10. Select needle force measurements are displayed in Images 11 through 16.

CT imaging demonstrated high Hounsfield units in the silicone materials (Images 2 & 5). The urethane foams all demonstrated very low Hounsfield units (Images 4 & 5). However, the silicone foams (Image 3) and the ballistic gels (Image 6) demonstrated intermediate Hounsfield units.

Ultrasound imaging demonstrated significant penetration in a number of materials (ballistic gel (image 10), gelatins, and silicone rubbers with slacker added, Image 8). The foam materials had limited penetration(image 9), as did the pure silicone rubbers (Image 7)

Force measurements demonstrate significant variability within and across material types. Among the materials, there is general consistency in 18ga needles requiring greater force than 22ga needles. An exception is the Flex Foam-It 7FR (Image 14). The force required in that material plateaus for an extended period as well. While Dragon Skin (Image 15) requires high force, the addition of Slacker (Image 11) significantly reduces the force required. The amount of this reduction increases as the portion of Slacker increases.

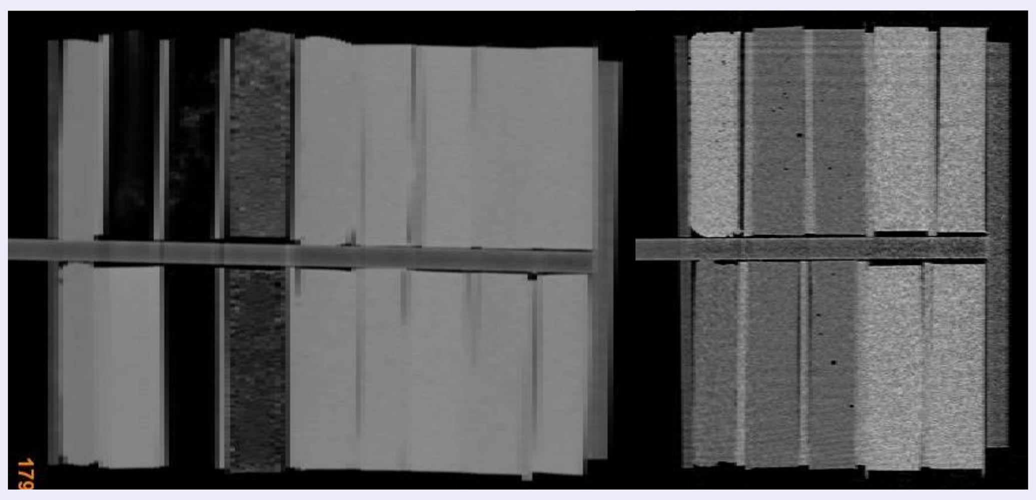

Image 1: Coronal View of the Tissue Samples, CT

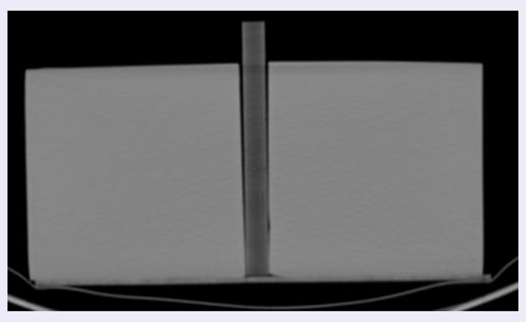

Image 2: DragonSkin 121 (L) and 343 (R), CT

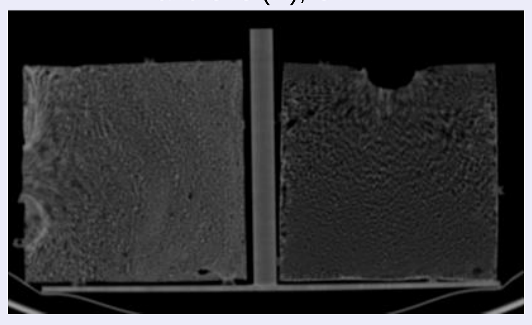

Image 3: Soma Foam 15 (L) and 25(R), CT

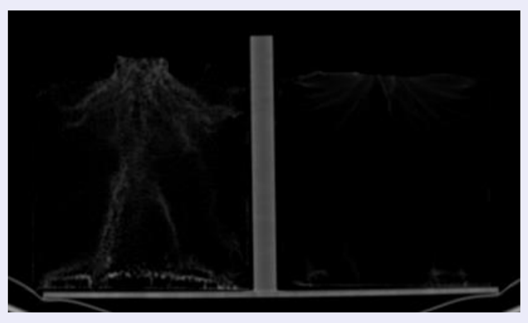

Image 4: Flex Foam-It X (L) and III (R), CT

Image 5: Flex Foam-It 7FR (L) and TAP Plastic silicone (R)

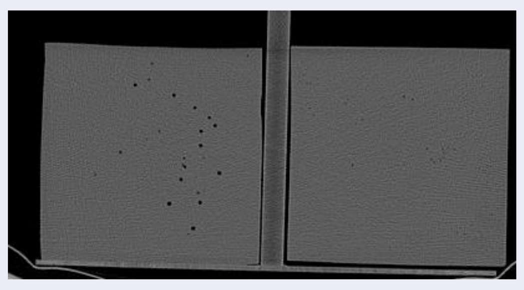

Image 6: Ballistic Gel 2 (L) And Ballistic Gel 3 (R)

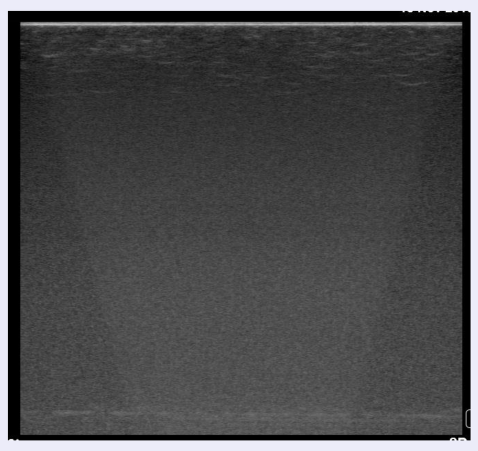

Image 7: DragonSkin 1:0:1, US

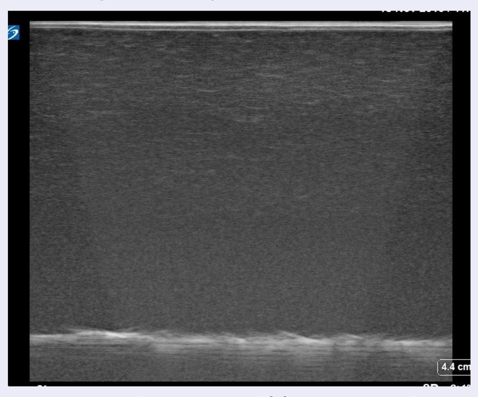

Image 8: DragonSkin 1:2:1, US

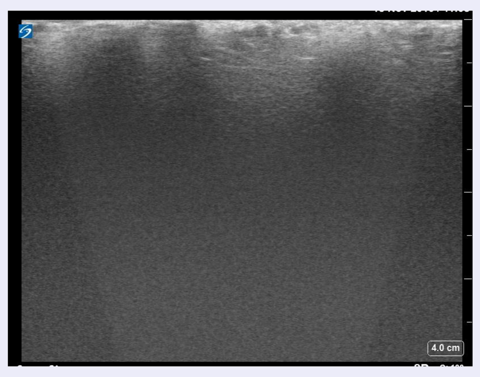

Image 9: Soma Foama 25, US

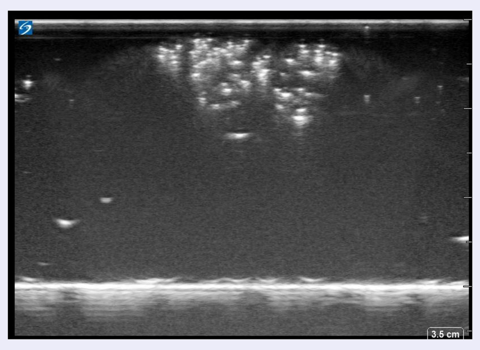

Image 10: Ballistic Gel O, US

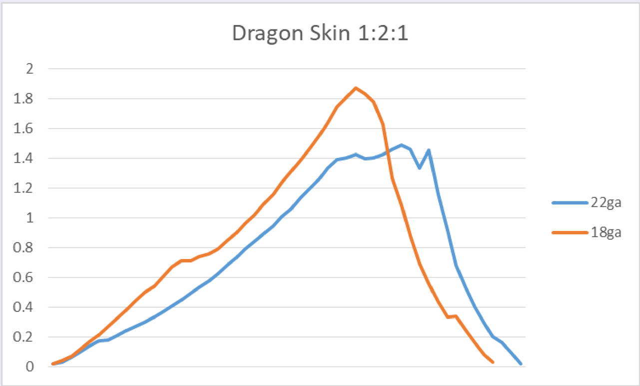

Image 11: Force measurement of DragonSkin 1:2:1

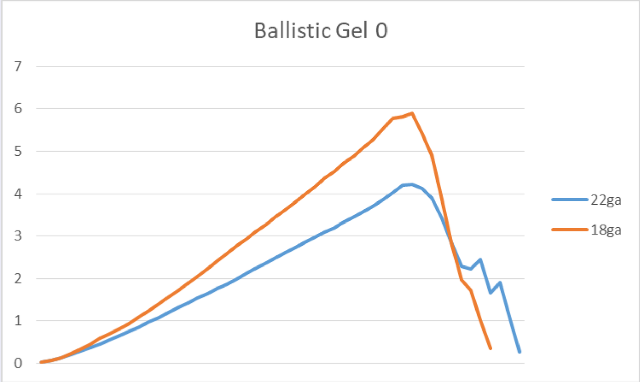

Image 12: Force measurement of Ballistic Gel 0

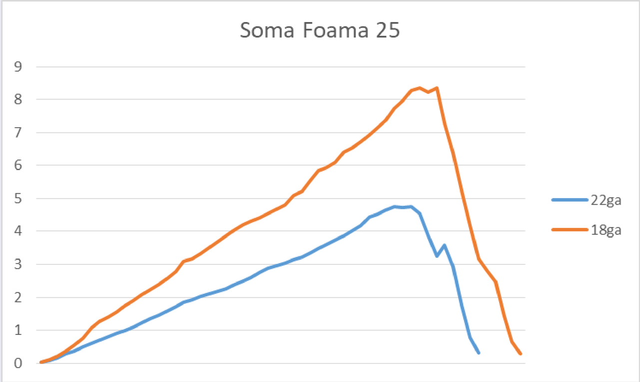

Image 13: Force measurement of Soma Foama 25

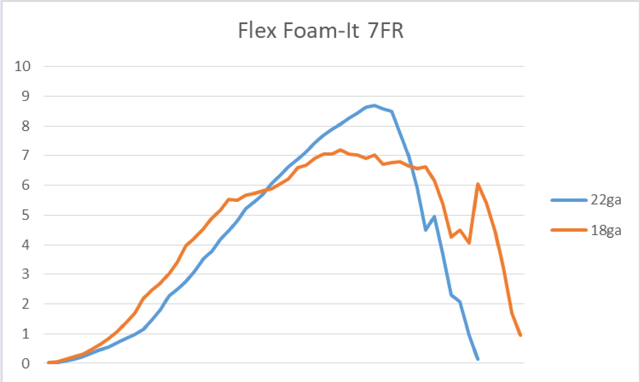

Image 14: Force measurement of Flex Foam-It 7FR

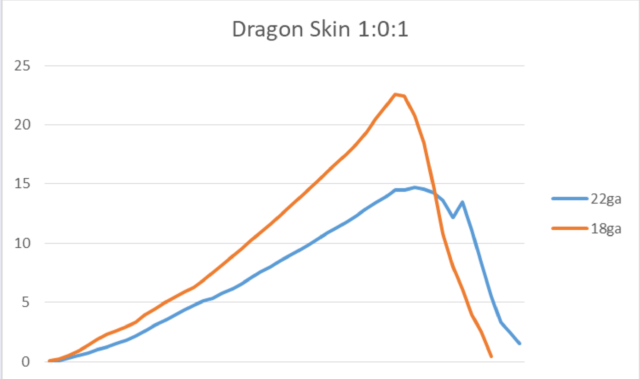

Image 15: Force measurement of DragonSkin 1:0:1

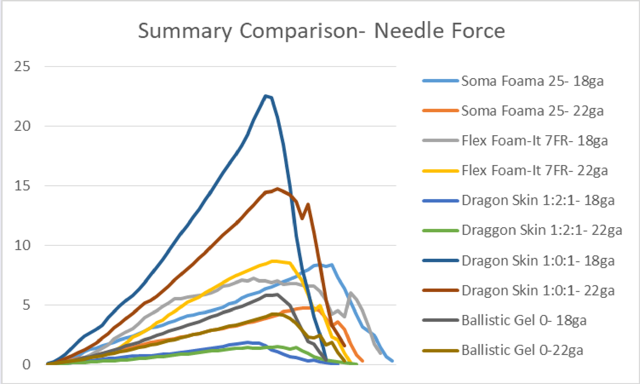

Image 16: Summary of force measurements

Conclusions

Imaging properties of the silicone rubbers were fairly uniform via CT. Ultrasound imaging also revealed fairly similar properties in the silicone rubbers, with some variation in with the addition of Slacker as well as internal appearance due to air bubbles, etc. Their bright appearance in CT imaging may make them difficult to use for CT simulations, but their wide range of needle force combined with clarity in ultrasound imaging makes them excellent candidates for US simulations.

The CT imaging of the urethane foams revealed a significant lack of opacity. Given the nature of a foam, this should not be very surprising. However, the silicone foams were significantly more opaque (Soma Foama 15 and 25). Given the foam structure, a high degree of noise in the ultrasound imaging is also to be expected and was found. Penetration of US in the foams was very limited. The foams hold potential for use in CT/ Fluoroscopic simulations.

The ballistic gels showed uniform appearance in CT imaging, with good conductivity in ultrasound. The mechanical strength of the gels/ gelatines raise issues of durability in simulants. However, these materials also seem the easiest to maintain/repair. This aspect was not examined in this project, however.

Future work will include identifying other available materials for analysis. Additionally, interactions of 3D printed materials and casting materials need to be examined together to help identify 'optimal' combinations for specific simulation goals.

References

1. Mooney J, Sarwani N, Coleman M, Fotos J: Evaluation of 3D Printed Materials for Simulation by Computed Tomography and Ultrasound Imaging. Simulation in Healthcare, Epub ahead of print
2. Ng KW, Goh JQ, Foo SL, Ting PH, Lee TK: Needle Insertion Forces Studies for Optimal Surgical Modeling. International Journal of Bioscience, Biochemistry and Bioinformatics, Vol. 3, No. 3, May 2013
3. Geng W, Cosman P, Berry C, Feng Z, Schafer W: Force Modeling for Needle Insertion Into Soft Tissue, IEEE Transactions On Biomedical Engineering, Vol 51, No 10, October 2004

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