segmentation software package (3D Slicer) and further modified in CAD software (Blender). Metacarpals and phalanges were created with polylactic material with an FDM style printer to mimic dense cortical bone surrounded by a lattice structure resembling cancellous bone. The bones were casted into a clear silicone, chosen to provide accurate density for proprioceptive feel in drilling procedures while still affording high tensile strength and durability.

RESULTS: Our device performs well in joint arthrodesis and CRPP under fluoroscopy. The hand provides excellent proprioceptive feedback to train pinning and plating due to the model’s dense cortical bone surrounding an intramedullary bone matrix. The silicone soft tissue is durable yet malleable allowing for the utilization of techniques such as Jahss maneuver or bone forceps. The model also gives high quality fluoroscopic imaging due to the discrepancies in density of the silicone soft tissues, dense cortical bone, and lattice structured intermedullary space. 3D printing using CT data provides accurate anatomy of the hand. Additionally, multiple fracture patterns and anatomic variations can be programmed into the model before printing offering a wide range of simulated clinical scenarios. The estimated cost of the device is between $200 and $300 making it significantly cheaper than high fidelity simulators or cadaver alternatives, while still providing high-quality training for motor skills and spatial reasoning.

CONCLUSIONS: With this hand simulator, we created a 3D printed, anatomically accurate, polyfracture model for resident education. Due to the model’s low cost and ability to represent a wide range of fractures and hand procedures, it has the potential to be an excellent tool in resident education. Future research with a pilot study is warranted.

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Harnessing Machine-learning to Personalize Cleft Lip Markings

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PURPOSE: Cleft-lip surgery aims to restore oral functionality while striving to achieve normal lip aesthetics. Preoperative planning using anthropological landmarks of the lip guide surgeons through the process. However, identifying and placing these markings on the fine anatomy of the lip in children can be extremely difficult and can lead to compromised functional and aesthetic outcomes. The purpose of the study is to develop a novel approach to improve the accuracy of markings for cleft-lip surgery. To do so, we developed a machine-learning algorithm which reliably places anthropological landmarks on unilateral cleft-lip pictures in order to guide intraoperative markings.

METHODS: We utilized High-Resolution Net (HRNet), a recent family of deep learning models that has achieved state of the art results in many computer-vision tasks, including facial landmark detection.¹ HRNet follows the current trend in computer vision of stacking multiple convolutional layers², but differs in one key area. Whereas previous models generally downsample the dimensionality of the input at each layer, HRNet performs this downsampling in parallel with a series of convolutional layers that preserves dimensionality, which allows for intermediate representations with higher dimensionality while simultaneously extracting lower dimension features. To adapt the facial landmark detection HRNet for our task, we employed transfer learning, a technique in machine-learning to transfer knowledge gained from a source task to a target task.³ Transfer learning has shown to dramatically reduce training time, increase accuracy on target task, and reduce required training examples in the target task.

RESULTS: For model evaluation, we calculated error using the Normalized Mean Error (NME), an evaluation metric in facial landmark detection. Here, a craniofacial plastic surgeon manually marked 50 Mulliken unilateral cleft-lip images, and these images are compared against the detected markings assigned by our algorithm. After training on our dataset, we obtained a test NME of 0.1065. In comparison, the state of the art for facial point detection test NME in other datasets is in the range of 0.0385 (300W) to 0.0460 (WFLW), but our training dataset size is about 1% the size of these benchmarks. These results illustrate the possibility of leveraging relatively small amounts of data to achieve surprisingly accurate labeling in cleft-lip annotations.
CONCLUSION: In the present study, we developed a deep learning model which accurately places Mulliken unilateral cleft-lip markings on to preoperative photographs. We envision a national and international impact and believe that the usefulness will go beyond teaching residents as this technology can be used by cleft global outreach foundations as an instructional resource application for trainees. In the future, we plan on physically projecting these markings onto the surface of cleft-lips, using technology developed by our team, thereby overcoming discrepancies related to paper to 3-dimensional marking transfer.

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FULL-THICKNESS SKIN MICROCOLUMN IMPLANTED INTO A DERMAL REGENERATION TEMPLATE: A NOVEL METHOD FOR “DONOR-FREE” SKIN REPLACEMENT THERAPY

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BACKGROUND: Split-thickness skin graft is the current standard in the treatment of large full-thickness skin defects. The donor site resulting from tangential skin harvest is well recognized as painful and unsightly, even after it has healed. Several efforts have been made in the past to address this problem by limiting the amount of skin harvested while significantly expanding the skin elements (ReCell, Meek). These efforts suffer from short comings such as graft fragility and failure to achieve adequate closure in a reasonable period of time. Full-thickness skin columns are a novel concept in skin harvest with little to no donor site when the diameter of the columns falls below a certain threshold. There is also a theoretical advantage that the columns harvested contain elements of full-thickness skin including sweat glands and hair follicles. Here, we present 2 cases where full-thickness skin columns were harvested and implanted into a bilayer dermal regenerative template (Integra) to achieve durable single-stage skin replacement.

METHODS: Wounds in 2 elderly patients were treated using standard excisional preparation techniques. Both patients refused a standard split-thickness skin graft with concerns of difficulty healing the donor site. Informed consent using full-thickness skin columns and Integra combination were obtained. Full-thickness skin columns were harvested from a small area of the upper thigh using skin biopsy punches (1.5–2 mm). The columns were implanted orthotopically into a sheet of Integra dermal matrix with the epidermis placed immediately deep to the silicone layer. The Integra-skin column composites were applied onto the wounds similar to a traditional skin graft. The punch biopsy donor sites were allowed to heal secondarily.

RESULTS: Patient 1 was 90 years old and had a small lower extremity wound treated with 2 mm skin columns (n = 9) and a 3 × 1.5 cm² Integra. Patient 2 was 88 years old had a larger volar forearm wound treated with 1.5 mm skin columns (n = 51) and an 8 × 5 cm² Integra. Visual evaluation showed centripetal healing with epithelial cells radiating from the columns as well as from the periphery. Complete healing was achieved in 3–4 weeks; donor sites healed in less than a week with minimal evidence of skin harvest at 1 month.

CONCLUSIONS: Full-thickness skin columns implanted into a dermal regeneration template represent a novel technique for skin replacement that allows single-stage healing of full-thickness skin wounds with little to no donor site, and without any biochemical processing of the tissue.