vascular, inflammatory and infectious complications in a mid-humerus porcine forelimb transplant model.

METHODS: Eight Yucatan miniature pigs, 4 donors and 4 recipients, were used. Right forelimbs of donor animals were amputated at mid-humeral level, to maintain integrity of forearm fascial compartments, and preserved with EVNLP until replantation. The right forelimb of the recipient animal was amputated, and a central venous line was placed in the contralateral neck. Perfusate electrolytes, gases, O₂ saturation, muscle contractility, surface temperature (infrared thermography), and peripheral perfusion (indocyanine green angiography) were assessed during EVNLP. The humerus was fixed with a single 3.5 mm LC-DCP plate; microsurgical anastomosis of the brachial artery, cephalic vein, and repair of radial, ulnar, and median nerves were performed under an operative microscope. Tendons of the biceps and triceps were repaired with pulvertaft weave technique. The first animal did not receive systemic immunosuppression. Systemic immunosuppression for the remaining 3 pigs included induction with antithymoglobulin, followed by daily cyclosporine (CSA), mycophenolate mofetil, and methylprednisolone. CSA trough levels were measured daily. Limbs were monitored clinically and histologically for signs of rejection. Bone healing was confirmed with CT scan at euthanasia. The endpoint of the study was 90 days.

RESULTS: Warm ischemia time during limb procurement was 20.6 ± 9 minutes and 2.2 ± 0.25 hours during limb transplantation. EVNLP lasted an average of 4.3 ± 0.52 hours. Total time to revascularize was 6.8 ± 0.5 hours. PO₂, pH, and lactate were 557 ± 72 mm Hg, 7.5 ± 0.1, 5.6 ± 0.9 mmol/L, respectively. Muscle contractions were 4/5 during EVNLP. All forelimbs were successfully transplanted with no vascular failure. CSA trough levels were on average 678 ± 450, 369 ± 445, and 336 ± 468 ng/ml. Animals 2, 3, and 4 developed septic thrombophlebitis of the central line, which was replaced on POD 14, 51, and 28. Animals 3 and 4 lost IV access on POD 54 and 64, respectively, and were transitioned to PO medications. The first transplanted limb (animal 1) showed evidence of acute rejection on POD 4 and the animal was euthanized on POD 6. In the remaining animals, the incisions healed and initial edema resolved by day 14. The third animal developed angioinvasive aspergillosis on POD 20 with 2 areas of full thickness skin necrosis of trunk. Voriconazol was started and the lesions were resected on POD 51. The animal lost the central line on POD 55, showed evidence of rejection on POD 57 and was euthanized on POD 60. Animals 2–4 showed bone healing and consolidation with the presence of bony callus on CT scans. At endpoint, animals 2 and 4 had reached complete weight bearing on the transplanted limb, at the hoof and wrist, respectively.

CONCLUSION: Extremity transplantation can be successfully performed following EVNLP. EVNLP does not increase the risk of vascular or infectious complications. The mid-humerus porcine transplantation model is feasible and reproducible.

Bone-Selective Magnetic Resonance Imaging as a Nonradiative Alternative to Computed Tomography for Cranial Vault Imaging: Concordance and Implementation of an Automated Segmentation Pipeline for Timely Image Processing

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BACKGROUND: Computed tomography (CT) is the clinical gold standard for high-resolution 3-dimensional (3D) visualization of cortical bone structures. However, CT ionizing radiation exposure is associated with the development of malignancy. Bone-selective magnetic resonance imaging (MRI) and bone-selective image reconstruction provide a radiation-free imaging modality with diagnostic and surgical planning uses. This technique, though applicable to many realms of plastic and reconstructive surgery, is of specific interest to craniofacial surgeons whose patients often require multiple pre- and postoperative CT scans, enduring a higher cumulative risk of malignancy. As it stands, the implementation of bone-selective MRI in clinical practice is prevented by a paucity of CT and bone-selective MRI concordance data and the time and labor intensive process required to produce bone-selective MR-based 3D skull segmentations. The manual segmentation process takes about 1.5 hours of time per MRI. Our study evaluates both the accuracy of a novel bone-selective MRI technique
(dual-radiofrequency pulse, dual-echo, 3D ultrashort echo time) and the utility of a segmentation pipeline.

**OBJECTIVES:**

**Part 1.** Evaluate the concordance between MR-based and CT-based 3D skull renderings

**Part 2.** Describe and evaluate a novel multiatlas segmentation pipeline

**DESIGN/METHODS:**

**Part 1:** A cadaver skull and the skulls of 5 healthy adult volunteers were scanned with bone-selective MR and thin-slice CT. Semi-automatic bone segmentation (1.5 hours/scan) was performed creating 3D renderings of the skulls. Mimics software was used to measure 8 anatomic distances from the 3D renderings. Lin’s Concordance Correlation test was applied to assess agreement between MR and CT-based 3D renderings.

**Part 2:** CT and bone-selective MR images were acquired from 16 additional healthy adult volunteers, yielding 21 MR/CT pairs. The CT images were segmented using a semi-automated method to generate “ground truth” labels for the MR images. An automated multiatlas segmentation pipeline was then used to segment the 3D MR images using a 2-step process consisting of a training and segmentation. The training step develops an “atlas package,” which represents the varying anatomy from different subjects. The segmentation step uses the atlas package to generate segmentations for new subjects using several image registration steps.

**RESULTS:** MR-based measurements differed from CT-based measurements by mean percent difference ranging from 2.3% to 5.0%. Lin’s Concordance Correlation ranged from 0.998 to 1.000. The segmentation pipeline took 10 minutes per segmentation with an average symmetric surface distance of 0.96 ± 0.15 mm between the manual reference segmentation and the corresponding automated segmentations.

**CONCLUSIONS:** This study demonstrates high concordance between the gold standard (thin-slice CT) and our novel imaging modality as well as an 89% reduction in segmentation time. This technique is highly applicable to craniofacial surgery as well as cases involving extremity surgery, musculoskeletal trauma, and bone tumors. It additionally allows acquisition of data of both soft and hard tissue structures from a single imaging modality with no radiation exposure. The demonstrated reduced segmentation time would allow bone-selective MRI to be used in clinical practice without a delay in treatment. We plan to investigate the accuracy of this technique as a tool for craniosynostosis diagnosis as well as in craniofacial virtual surgical planning.

**Silicone Implant Shells Increase the Rate of Proliferation of Alk- but Not Alk+ Lymphoma Cells in an Engineered Biomimetic Breast Microenvironment**

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**PURPOSE:** The pathogenesis of breast implant-associated anaplastic large cell lymphoma (BIA-ALCL), an Alk-pathology, remains poorly understood. Our lab has demonstrated the power of studying BIA-ALCL behavior in a high-fidelity tissue engineered ex vivo biomimetic, 3-dimensional model. Herein we use this model to study the behavior of Alk+ Lymphoma cells, which characterize the most common type of ALCL, within an engineered breast microenvironment, to serve as an important comparator to the behavior of BIA-ALCL cells, which are Alk-.

**METHODS:** Patient-derived breast tissue was processed for its component adipocytes, ductal organoids, and stromal vascular fraction. These were suspended within 50 µl of 0.3% Type I collagen matrix to which was added 200,000 cells/ml of Alk+ Lymphoma cells. These were then plated into 6 mm wells. As a control, Alk+ Lymphoma cells were also suspended within Type I collagen alone at the same seeding density without breast components (“collagen only”). Before plating, wells were lined circumferentially with 1 cm by 2 cm pieces of either textured, smooth, or no implant shell (dissected from the intact implant). Wells were imaged using confocal microscopy over 8 days.

**RESULTS:** There was a significant difference in cell counts over 8 days between the 6 different groups ($P = 0.002$; $R^2 = 0.625$). Cell proliferation over time in the biomimetic groups, regardless of the presence or absence of implant shell, was significantly greater than cell proliferation in the collagen only groups over the same time period.