HI-FI Tissue Engineering: Custom 3D-Printed Cages with Anatomic Elements Prevent Loss of Volume and Topographic Detail of Engineered Auricular Cartilage In Vivo

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PURPOSE: Autologous reconstruction of the ear, whether for microtia or acquired deformity, is a complex procedure with substantial donor site morbidity and frequent suboptimal aesthetic outcomes. An engineered auricular scaffold would obviate donor morbidity and provide improved aesthetic outcomes. Currently, clinical translation of tissue-engineered auricles is complicated by the significant contraction and loss of topography that occurs during maturation of the cell-seeded hydrogel into elastic cartilage. Previously, we demonstrated that a 3D-printed biodegradable cage significantly mitigated contraction of simple disc-shaped collagen hydrogels seeded with human auricular chondrocytes (HAuCs) in vivo without impeding the development of elastic cartilage. Herein we fabricate cages to invest chondrocyte-collagen hydrogels with more intricate “anatomic” topographic features.

METHODS: Custom external cages were designed with a geometric element representative of the helical rim using SolidWorks (Dassault Systèmes, Vélizy-Villacoublay, France), then 3D-printed using polylactic acid (PLA) on a 5th generation MakerBot printer (MakerBot, New York, NY). Using auricular cartilage from freshly slaughtered 1-3d old calves, bovine auricular chondrocytes (BAuCs) were harvested and expanded to passage 3. The chondrocytes were then encapsulated at a density of 25 million cells per mL into type I collagen hydrogels with high fidelity contour matching to the cages. The hydrogels, either protected or unprotected by the PLAC cages, were implanted into nude rats and explanted after 3 months.

RESULTS: After 3 months in vivo, all constructs developed a glossy white cartilaginous appearance, similar to native auricular cartilage. Histologic analysis demonstrated development of an organized perichondrium composed of collagen, a rich proteoglycan matrix, cellular lacunae, and a dense elastin fibrin network by safranin-O and Verhoeff’s stain. Biochemical analysis confirmed similar amounts of proteoglycan and hydroxyproline content in the constructs when compared to native auricular cartilage. Cage-protected constructs contracted significantly less than unprotected constructs on base area comparison (14.33% vs. 56%, p = 0.0023), retained volume (213.4mm³ vs. 117.2mm³, p = 0.0290), and maintenance of the topographic “helical rim” feature compared to unprotected constructs. Constructs were imaged via computed tomography with an Inveon Pre-clinical MicroPET/CT/SPECT (CTI/Siemens, Knoxville, TN), then digitally reconstructed with Imaris (Bitplane, Belfast, UK). Preservation of the “helical rim” feature was evaluated subjectively by gross examination and objectively by measuring the angle between the rim and base of the constructs. There was significantly more flattening of the helical rim element in the unprotected constructs versus caged ones (197.7° vs. 151.8°, p = 0.0445).

CONCLUSION: We have shown that custom contour matched 3D-printed biocompatible/biodegradable external cages significantly mitigate contraction and maintain the complex topography of BAuC constructs without impeding the formation of mature elastic cartilage. This technique can be used to create custom cages that contour to any form, enabling the fabrication of engineered autologous cartilage tailored to individual patient anatomy, without the significant contraction and loss of topography that has thus far impeded translation of this technology to the clinic.

Salvage Dynamic Smile Reanimation with Reuse of the Massteric Nerve

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PURPOSE/SUMMARY: Failed dynamic smile reanimation in patients with long standing facial paralysis has devastating psychosocial ramifications and poses significant
challenges for the surgeon. There are multiple approaches to salvage dynamic function in patients with failed Free Functional Muscle Transfers (FFMT), however, there is a paucity of literature to help guide the surgeon in choosing a specific salvage modality. The objective of this study is to demonstrate the feasibility, describe the surgical technique, and assess the results of one such approach that had previously not been described – the reuse of the masseter nerve to re-innervate a new FFMT.

METHODS: Patients who presented between 2007 and 2017 to a single center after previously failed dynamic smile reanimation using the masseteric nerve who underwent a salvage dynamic procedure involving re-use of the masseteric nerve were analyzed. Additionally, patient demographics, history of radiation or chemotherapy, surgical techniques, and objective measurements using the MEEI Facegram software were evaluated.

RESULTS: The average duration of palsy was 6.2 years, and the average pre-operative HB score was 6. Etiologies of palsy included one patient with Bell’s palsy, two with parotid malignancies, and one with a CN7 schwannoma, with two patients requiring radiation preoperatively. Three patients failed to achieve any motion after one-stage reanimation with a FFMT to the masseteric nerve. The fourth patient initially achieved excursion, however, due to cancer recurrence and resection of FFMT, motion was subsequently lost. In one case, neurolysis of the masseteric nerve at the area of previous coaptation led to motion 8 days after surgery, while the others achieved motion an average of 4 months after re-dissection of the masseteric nerve and coaptation to a new FFMT. Overall this series achieved 11.32 mm of smile excursion on the paralyzed side with a 1.3 mm philtral deviation correction in repose.

CONCLUSION: Dynamic smile restoration with FFMT in previously failed reanimation patients is feasible. Careful patient evaluation and clear understanding of previous procedures is key to success. Use of a new donor nerve, a previously used donor nerve, and rarely, neurolysis of a previous FFMT nerve coaptation, may all provide successful reanimation.

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Evaluation of 3D Printed Cleft Lip and Palate Models in Plastic Surgery Education

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BACKGROUND: Modern plastic surgical education is challenged with increasing work hours restrictions, attainment of milestones for graduated responsibility, and a general decrease in operative independence. These challenges require residency programs to define new methods for delivery of education efficiently and preoperatively to augment the intraoperative surgical experience. We evaluated an approach using a three-dimensional printed cleft lip and palate silicone model for haptic simulation surgery in a laboratory setting.

METHODS: Three-dimensional modeling and printing of a unilateral complete cleft lip and palate model was performed and tested at two accredited plastic and reconstructive surgery residency programs. A standardized modified Millard cleft lip repair course was developed for model surgery and proctored by a craniofacial surgery faculty.