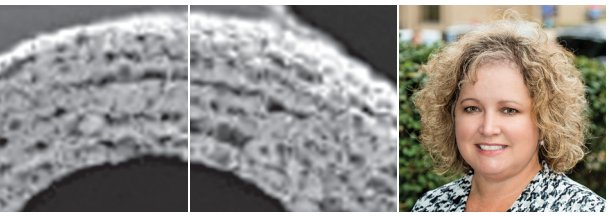
# AxoMax®: A Novel Conduit for Enhanced Nerve Repair



KACEY MARRA, PHD
*University of Pittsburgh*

*"This technology has the potential to revolutionize treatment of long gap nerve repair."*

***https://www.mirm.pitt.edu/our-people/faculty-staff-bios/kacey-g-marra-phd***

## CLINICAL NEED

Injuries resulting in facial paralysis significantly affect a patient both physiologically and psychosocially. The standard of care for nerve injury requiring surgical repair is nerve autograft, which is suboptimal for various reasons. While several nerve guides are commercially available for regeneration of nerve gaps <3cm, those for use in large nerve gaps (>3cm) are not. Furthermore, despite the available interventions, current cases of nerve autografting or allografting result in insufficient functional recovery, where ~50% of patients are unable to return to pre-injury employment 1 year post-operation.

## SOLUTION

Kacey Marra, PhD, and her team at the University of Pittsburgh have developed a novel conduit for long-gap nerve repair, named AxoMax®. AxoMax® consists of a degradable poly(caprolactone) nerve guide capable of controlled local delivery of drugs for nerve regeneration. Evaluation of the AxoMax® in a 5cm median nerve defect model showed ~80% return to function after one year.

## COMPETITIVE ADVANTAGE

Unlike decellularized technologies, AxoMax® elutes factors essential to nerve growth for several months, rendering it biologically similar to an autograft, the standard of care, without the need for a surgery to harvest the graft, thereby avoiding comorbidities associated with such procedures. The elimination of the harvesting procedure spares the patient from lifelong loss of sensation, as well as operating room time, saving an excess of 60 minutes per case.

## ITP SUPPORT

With the ultimate goal of commercialization of AxoMax® for bridging craniofacial nerve defects, the work supported by the ITP program includes continued market validation and biocompatibility testing in support of a Q-submission to the FDA.

## CLINICAL TRANSLATION PATHWAY

**Publications:**
Incorporation of double-walled microspheres into polymer nerve guides for the sustained delivery of glial cell line-derived neurotrophic factor. Biomaterials, 2010.

Sustained Growth Factor Delivery Promotes Axonal Regeneration in Long Gap Peripheral Nerve Repair. Tissue Eng Part A. 2011.

**Intellectual Property:**
US 9,498,221
Implantable medical devices having double walled microspheres.

**Regulatory Pathway:**
Anticipated: Device, 510(k), then IDE to enable PMA

**Commercialization Strategy:**
Technology licensed by AxoMax Technologies, Inc., a start-up company founded to advance AxoMax®

**Product Launch Strategy:**
In development with the MPWRM Commercialization/ Market Needs Core

*Michigan-Pittsburgh-Wyss Regenerative Medicine Resource Center is supported in part by the National Institute of Dental & Craniofacial Research of the National Institutes of Health under Award Number U24DE026915. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health.*

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# A Novel Conduit that Enhances Nerve Repair

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DOCTRC DENTAL, ORAL, & CRANIOFACIAL TISSUE REGENERATION CONSORTIUM
Michigan · Pittsburgh · Wyss Regenerative Medicine Resource Center
Annual Retreat 2020 | December 8, 2020

## UNMET CLINICAL NEED

Injuries resulting in facial paralysis significantly affect a patient both physiologically and psychosocially. The standard of care for nerve injury requiring surgical repair is nerve autograft, which is suboptimal for various reasons. While several nerve guides are commercially available for regeneration of nerve gaps >1") are not. Furthermore, despite the available interventions (Figure 1), current cases of nerve autografting or allografting result in insufficient functional recovery, where ~50% of patients are unable to return to pre-injury employment 1 year post-operation.

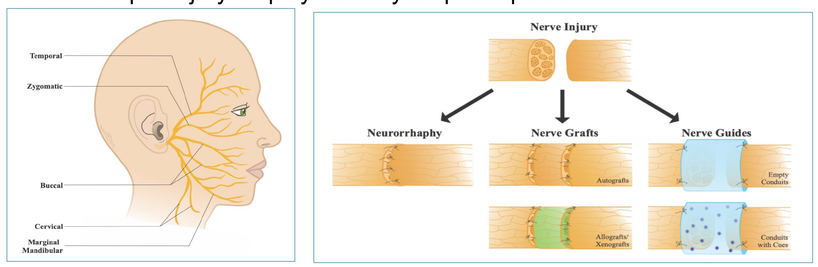



**Figure 1.** A) Schematic of human facial nerve anatomy. B) Current strategies for peripheral nerve repair.

## MARKET ANALYSIS

### Global nerve repair market: $2.7B[1]

- Over 20M people worldwide suffer from nerve damage[2]
- Over 800,000 surgical nerve repairs annually in the US[3]
- Small gap nerve repair: $283M[4]
- Large gap nerve repair: $668M[4]

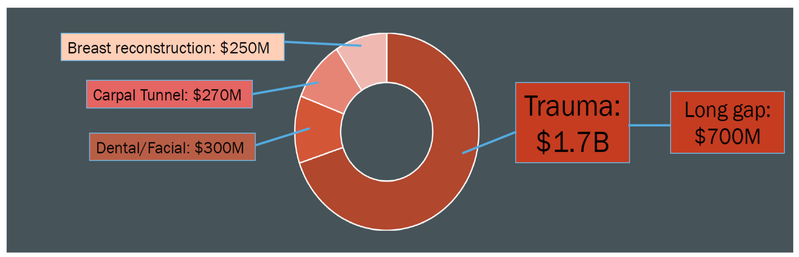


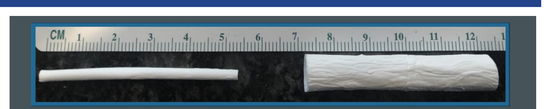

**Figure 2.** Total addressable market for peripheral nerve repair.

## INTELLECTUAL PROPERTY

**INTELLECTUAL PROPERTY SECURED**

We have licensed our technology from University of Pittsburgh:

- ***Issued Patents:*** *9498221, 9750851, PCT/US2011/051053*
- ***Filed Patents:*** *16/763,753, PCT/US2018/060788, 15/668,959, PCT/US2020/023708*




LibertyTube™ Nerve Guides for facial (left) and extremity (right) nerve repair

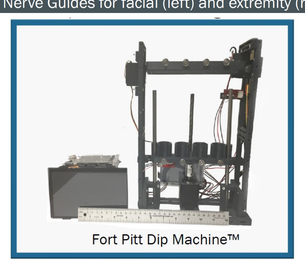



**Figure 3.** Portfolio of products at AxoMax Technologies.

## RESULTS

We have initiated the rat facial nerve repair study as well as mechanical testing with Dr. Alex Almarza's Laboratory. Figure 4a is a schematic of the rat facial nerve anatomy while Figure 4b is the actual rat dissection.

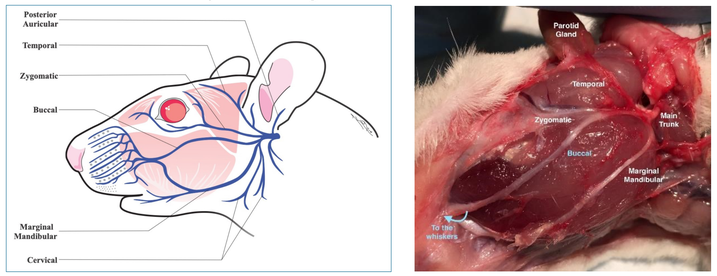



**Figure 4.** A) Schematic of rat facial nerve anatomy. B) Rat facial nerve dissection in our laboratory.

We will measure functional recovery by recording whisker movement. Figure 5a is a photo of a rat with one whisker marked in black, while Figure 5b is a restraint we will use while recording whisker movements.

**Figure 5.** A) Whisker identified with black ink for tracking. B) Head restraint to be used for accurate whisking studies.

Figure 6 depicts the testing of the nerve guides in Dr. Almarza's laboratory. Suture retention strength, per ISO 7198:1998, will determine the ability for the device to hold a suture under increasing tensile load normal to the longest axis. We will include the mechanical testing results in our regulatory application to the FDA for the first clinical trial.

**Figure 6.** Nerve guide with suture connected to an eyebolt to the Instron machine.

## MANUFACTURING

We are working with Surgical Technologies, Inc. (STI) to produce our nerve guides under GMP manufacturing for the first clinical trial. Figure 7 depicts the packaging system that our lab as well as STI has developed.

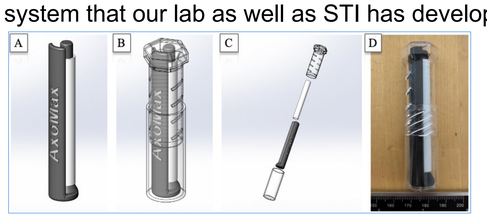



**Figure 7.** The guide stand (A and B) was custom-designed in our lab for supporting the nerve guide within the pre-validated screw-out package, (C and D) which was provided by STI.

STI is a member of the Scanlan Group, a unique combination of enterprising businesses dedicated to providing the highest quality products and services to the medical community.

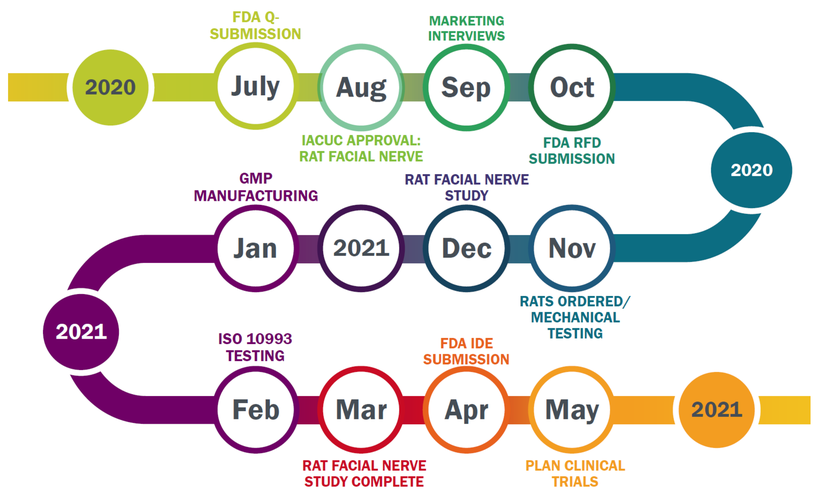
## REGULATORY PATHWAY

### Office of Combination Products

| Q2 2020 | Q3 2020 | Q4 2020 | Q1 2021 | Q2 2021 |
|---|---|---|---|---|
| Submission of Q-Sub (ie pre-IDE [Investigational Device Exemption]) to CDRH [Center for Devices and Radiologic Health] | Response from CDRH to Q-sub: Submit RFD [Request for Designation] to Office of Combination Products [OCP] | Submitted pre-RFD to FDA OCP | Based on FDA OCP Response: Initiate IDE or IND [Investigation New Drug] | Submit IDE (or IND) to FDA OCP |

Our regulatory timeline for the next year is depicted above. We have had multiple phone conferences with both the Center for Devices and Radiologic Health (CDRH) and the Office of Combination Products (OCP) over the past 5 months, and we are on a pathway to an Investigational Device Exemption (IDE). However, if the OCP determines that our nerve guide is to be regulated as a drug, we will pivot and submit an Investigational New Drug (IND) application.

## TIMELINE & FUTURE DIRECTIONS




## REFERENCES

[1]Grandview Research, 2018; [2]Transparency Market Research; [3]Kasper et al, Adv. Healthcare Mat,2020; [4]Brattain, 2013,Magellan Medical Group Market Analysis, https://www.semanticscholar.org/paper/ANALYSIS-OF-THE-PERIPHERAL-NERVE-REPAIR-MARKET-IN-Brattain/cba129fbda15780ea0abd09da3da97de04f9c6b5?p2df

Funding sources: MPWRM; AxoMax Technologies Pre-Seed Round