BACKGROUND: Plastic surgeons have an increased risk for the development of musculoskeletal disorders due to the poor ergonomics of the operating room. A sustained downward gaze is common during plastic surgical procedures, which can create a painful, non-anatomic loading force on the neck. The detrimental effect is compounded by the use of heavy surgical loupes or head lamps while operating. This study characterized selected plastic surgery procedures, with an attempt to identify high-risk procedures and procedural components and to ascertain the impact of biofeedback on surgical ergonomics.

METHODS: A commercially available posture-training device was used to initially record neck and spine positioning and later to send biofeedback to prompt surgeons to correct posture. Device data were correlated with in-person observations to characterize factors associated with more time spent in the slouched/non-neutral cervical and thoracic spine posture.

RESULTS: An analysis of variance showed that proportion of time spent in the upright position during surgery yielded significant variation among male and female participants ($P < 0.001$), level of training ($P < 0.001$), participant height ($P = 0.009$), sitting versus non-sitting positioning ($P = 0.01$), and loupes use ($P = 0.04$). Role in surgery, surgery subtype, and headlight use were not found to be statistically significant. There was a statistically significant difference in time spent in the upright/neutral cervical and thoracic spine position (mean $= 0.70 \pm 0.285$) if there was more than an eight-inch height difference between two participants compared with surgeries where there was not a large difference in height (mean $= 0.854 \pm 0.172$) ($t(57) = 3.259$, $P = 0.02$).

Using the device intervention, all participants spent a larger proportion of operating time upright. Four of these participants (50.0%) experienced a statistically significant improvement in posture ($P < 0.05$). While in training mode, participants experienced shorter and more frequent periods of slouching/non-neutral posture. While in feedback mode, participants experienced shorter and more frequent periods of slouching/non-neutral posture. When comparing the same participant performing the same procedure with and without device biofeedback, 72.2% of participants spent more time in the upright/neutral posture during the surgery when the device was sending feedback.

CONCLUSIONS: Many surgeons experience negative health impacts due to the poor ergonomics of the operating room. Biofeedback devices utilized in the operating room can lead to improved surgical posture, which may translate to reduction of workplace injuries, and overall physician health. This study found that a commercially available posture-training device and sitting stools in the operating room could significantly improve physician cervical and thoracic spine posture.

Predicting Nipple–Areolar Complex Necrosis in Nipple-sparing Mastectomy with a Machine Learning Model

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BACKGROUND & OBJECTIVES: Necrosis of the nipple-areolar complex (NAC) is the Achilles’ heel of Nipple Sparing Mastectomy (NSM).¹ Our goal was to create a user-friendly, validated technology platform that surgeons could utilize preoperatively to predict which patients are at risk of NAC necrosis and aid in shared decision-making. This prediction would be based on patient characteristics and intraoperative variables.

METHODS: We conducted a retrospective review of all NSM with immediate reconstruction performed at our institution between January 2015 and July 2019. Preoperative clinical characteristics, operative variables, and postoperative complications were collected and linked to NAC outcomes. These results were utilized to train a Random Forest machine learning model to predict necrosis when given preoperative patient characteristics, including age, BMI, smoking status, medical history, previous breast incisions, breast size, and planned implant or tissue expander (TE) size. Our model was subsequently validated by predicting NAC outcomes in a prospective cohort. The prospective cohort included all therapeutic and prophylactic NSM performed at our institution from May 2020 through October 2020.

RESULTS: 305 breasts in 181 patients were included in the retrospective dataset which served as the foundation for our machine learning model. Full-thickness skin necrosis including part or all of the NAC occurred in 46 cases (15.1%). The strongest predictors of NAC necrosis were implant weight ($P < 0.001$) and weight of the mastectomy
specimen \( (P < 0.001) \). When controlling for implant volume in our model, fill weight maintained a strong association with NAC necrosis. Rates of NAC necrosis among TE reconstructions using air only were lower at equivalent volumes compared with TE using saline fill and direct to implant reconstructions. Other influential factors included diabetes \( (P = 0.005) \), smoking \( (P = 0.04) \), and hypertension \( (P = 0.03) \). With a prospective cohort of 27 patients, our predictive machine learning model achieved 96% accuracy \( (P = 0.02) \) with high positive predictive value and specificity for NAC necrosis. The model correctly predicted 4 of 5 cases of NAC necrosis and all 22 cases without necrosis.

**CONCLUSIONS:** Implant weight is an independent risk factor for NAC necrosis following NSM, indicating that lower implant volumes, or using air-only initial TE fill, may mitigate the risk of NAC necrosis. The findings of our predictive Random Forest machine learning model also provide a basis for utilizing artificial intelligence to predict cases with a high probability of NAC necrosis. We created an easy-to-use interface for our model, which allows a user to input patient characteristics and receive a prediction which includes a binary outcome: “NAC Necrosis” or “No NAC Necrosis” and the predicted probability of necrosis. Such models may be developed using institutional data and utilized to inform patient decision-making prior to mastectomy.

**REFERENCE:**
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**Extended Local Release of Neuromodulators from a Novel Nanoparticle System for Chronic Migraine and Facial Aesthetics**

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**PURPOSE:** Neuromodulators of the botulinum toxin family (eg, Botox) have been used effectively to treat a wide range of conditions, including chronic migraine, spasticity, hyperhidrosis, and facial rhytids. Despite their broad utility and commercial success, these agents suffer from two significant shortcomings: limited duration of effect, necessitating frequent redosing, and diffusion from target sites leading to unwanted muscle paralysis. To overcome these challenges, we have developed a novel nanoparticle-based botulinum toxin system that prolongs therapeutic effects while preventing off-target activity.

**METHODS:** Botulinum toxin A (BoNTA) and BoNTA toxoid (chemically inactivated form of the toxin) were each encapsulated within polymeric nanoparticles. BoNTA or toxoid was mixed with a carrier molecule and assembled into polyelectrolyte complex nanoparticles using a biodegradable amphiphilic block copolymer using a flash nanoprecipitation process.1 Nanoparticles were characterized by dynamic light scattering for size distribution and zeta potential, and transmission electron microscopy for morphology. In vitro release of BoNTA or toxoid was determined using ELISA and bioactivity of released BoNTA was analyzed using a substrate hydrolysis assay. The in vivo paralytic effect of BoNTA nanoparticles was assessed using a quantitative rodent forepaw model using stimulated grip strength testing.2

**RESULTS:** The BoNTA and its toxoid both demonstrated high encapsulation efficiency of 83%–88% of the input protein into NPs; and the average loading level (mass of total protein/mass of NPs) was 13.4–14.2%. Both NPs showed a similar, sustained linear release profile with 30%–35% of protein released within 30 days, ~75% in 98 days, and a projected release duration of about 4 months. Critically, BoNTA released from NPs demonstrated high levels (>80%) of bioactivity retention, confirming that the encapsulation process and release did not impair the bioactivity of BoNTA. Reference protein-loaded NPs showed superior localization when injected in rodent models when compared with unencapsulated proteins. Finally, the NPs stored at ambient temperature (20°C–25°C) for 70 days exhibited a similar release kinetics, demonstrating a good shelf stability.

**CONCLUSIONS:** We demonstrated a novel NP-based neuromodulator system that enables local, linear, long-acting neuromodulator release with strong preservation of bioactivity. Given the high level of potency of BoNTA and the linear release above the EC50 for almost 4 months, we anticipate powerful extended neuromodulatory effect in vivo with this formulation. It is hoped that clinical translation of