Cranial Neural Crest Control Timing of Bone Mineral Density and Microarchitecture in Development: Preliminary Results

H. Mumtaz, M. Gonzalez, and E.E. Bumann

University of Missouri-Kansas City, Department of Oral and Craniofacial Sciences, Kansas City, MO (USA)

Aims
Patients with craniofacial abnormalities, trauma, and cancers of the lower jaw undergo invasive surgical corrections. Fully understanding jaw bone development is crucial to develop non-surgical options for these patients. Osteoblast lineage cells, which build bone, are derived from cranial neural crest (CNC) in the mandible. The aim of this study was to determine if the CNC control bone mineral density (BMD) and microarchitecture of jaw bone to begin to develop non-surgical options for patients.

Methods
Our lab uses a unique avian chimeric transplant system that exploits the distinct species-specific anatomies of quail and duck, which differ noticeably in their morphology and maturation rate. We capitalize on the differences between quail and duck by transplanting duck CNC into quail (termed duail), or conversely quail CNC into duck (termed quck), to allow us to readily assess the extent to which donor CNC instruct jaw morphogenesis. Quail have shorter beaks and take 17 days to hatch whereas duck have longer beaks and take 28 days to hatch. Japanese quail and white Pekin duck eggs were incubated at 37°C and embryonic mandibles were collected at early bone deposition (HH36) and remodeling (HH39) stages. Duail mandibles were collected at HH39. Published data from our lab demonstrates that CNC controls jaw size and growth rate in a species-specific manner. For example, donor duck CNC produce a longer duck-like jaw skeleton that is delayed 3 stages in a quail host (chimeric duail). Differences can be readily detected at the anatomical level using various 3D imaging modalities, such as the Bruker Skyscan 1275 µCT scanner. For this study, BMD, BMD distribution, bone surface to bone volume (BS/BV), trabecular-like thickness (Tb.-like Th), and Tb.-like Th distribution were analyzed.

Results
A significant increase in BMD was detected between HH36 and HH39 in both duck (p<0.00001) and quail (p<0.0001), as well as denser bone in duck compared to quail at HH39 (p< 0.05). Chimeric HH39 duail had similar density and BMD distribution to HH36 quail and duck. A significant decrease in BS/BV was identified between HH36 and HH39 in both duck (p< 0.001) and quail (p< 0.01), and chimeric HH39 duail was again more like stage HH36. A significant increase in Tb.-like Th was likewise identified between HH36 and HH39 in both duck (p< 0.05) and quail (p<0.05), as well as thicker Tb.-like structures in the quail compared to the duck at HH39 (p<0.05). Chimeric HH39 duail has Tb.-like Th and Tb.-like Th distribution comparable to that of HH36.

Conclusions
We establish that CNC controls the timing of jaw bone mineral density and microarchitecture. Future studies will increase the number of chimeras to look at species-specific control and molecular studies are already underway to determine the precise mechanisms in how the CNC control these properties.