Mechanobehavior and Ontogenesis of the Temporomandibular Joint

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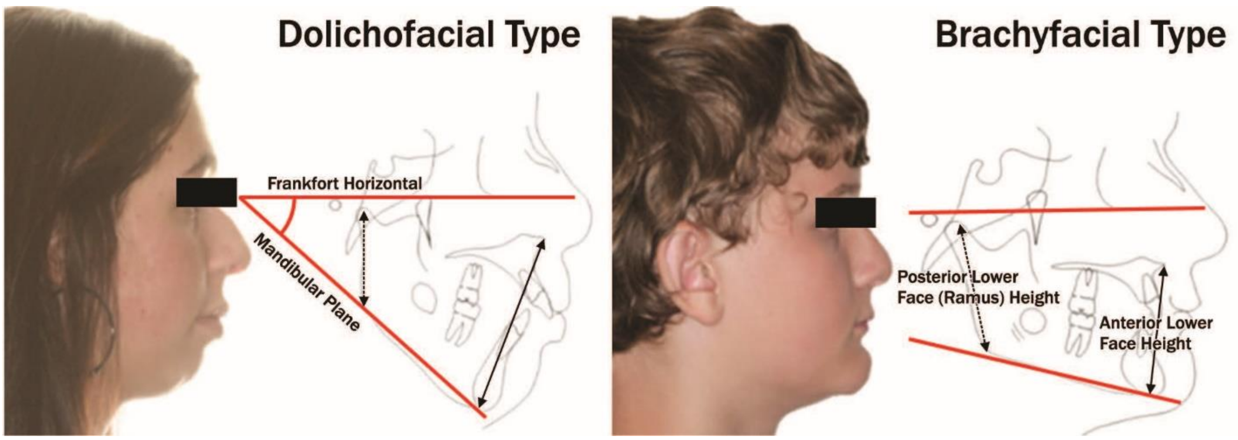
Appendix



Appendix Figure 1: Morphological Differences between Dolichofacial and Brachyfacial Phenotypes. Children with dolichofacial features (aka. Long-narrow, hyperdivergent or "unfavorable" growth type) have relatively long anterior and short posterior lower face heights while those with brachyfacial features (aka. Short-wide, hypodivergent or "favorable" growth type) have the opposite relationships. These distinctive facial characteristics manifest as mandibular ramus heights and angulations of the mandibular lower border to cranial reference lines (Mandibular Plane Angle) that are relatively short and steep, respectively, in dolichofacial phenotypes and relatively long and flat, respectively, in brachyfacial phenotypes.

Appendix Video 1: Dynamic stereometry of TMJ stress-field translation. The animation figure is a view from a superior aspect, with transparency of the glenoid fossa, TMJ eminence and disc. Dynamic stereometry was used to record the movement of the right TMJ of a subject during symmetrical opening and closing. Methods used to track jaw movement, and reconstruct and animate 3D renderings, have been described previously (Gallo et al. 2018). The black tear drop identified the estimated centroid of the right TMJ loading area (stress-field) consequent to a load applied to the right mandibular canine. During movement, the stress-field tracks along the mediolateral axis of the condyle. Based on these findings, laboratory experiments were done to measure the magnitudes of tractional forces (plowing) due to fluid pressurization of the TMJ disc. Magnitudes of plowing forces were found to be dependent on variables such as velocity of stress-field translation (Nickel et al. 2004).

Appendix Video 2: Biphasic finite element (bFE) modelling of *in vitro* plowing tests (Wu et al. 2017). The model was used to simulate previous experiments (Nickel et al. 2004) in order to establish load carriage between the solid and fluid phases of the disc, and the directions and velocities of fluid movement during plowing. A static normal compressive force (10 N) was added to the indenter once the simulation started, then kept constant through the entire duration of the loading periods. The indenter was oscillated (3.5 Hz) along the medial-lateral direction of the disc, which produced velocities and directions of stress-field translation similar to that seen in human subjects. The color scheme used in the animation demonstrated the dynamic distributions of solid stresses (MPa, top panel) and fluid pressures (MPa, bottom) inside the TMJ disc during the plowing tests. The findings showed that the fluid phase of the extracellular matrix carried approximately 60% of the load. This reduced the likelihood of mechanical fatigue by lowering mechanical strains imposed on the collagen and glycosaminoglycan components of the matrix. The arrows indicated regional directions and velocities of fluid movement. The anisotropic temporospatial fluid vectors may be a contributing factor to the stratification of Proteoglycan 4 and Indian hedgehog gene expression seen in the TMJ disc (Hinton et al. 2015). Also concerning regional differences in fluid vectors, it was noted that vertical movement of fluid out of the disc, perpendicular to the surface of the indenter, was consistent with articular cartilage weeping lubrication theory (Nickel et al. 2004), where pressurization of fluid between articulating surfaces produces very low classical frictional forces. Overall, the results of *ex viv*o experimental and modeling experiments demonstrated that the plowing forces, which were 10-times higher than frictional forces, were the most likely source of tractional forces associated with mechanical fatigue of the TMJ disc.