INTRODUCTION: Mandibular distraction osteogenesis (DO) is often a more complicated procedure than long bone lengthening. This is due to the complex three-dimensional distraction necessary to alter both the size and shape of a mandible, as compared to the primarily unidirectional lengthening of a long bone. Therefore, investigations into pre-operative computer planning, finite element (FE) modeling, and mathematical modeling of mandibles and mandibular DO have greatly escalated as researchers attempt to better determine, in a noninvasive manner, the most appropriate mandibular DO procedure for each patient prior to initiating surgery. With this in mind, in this study we use computed tomography (CT) image data to create FE models as we analyze rat mandibular DO at four time points during a DO protocol (Fig. 1): end latency (post operative day (POD) 5), distraction day 2 (POD 7), distraction day 5 (POD 10), and distraction day 8 (POD 13). Our research questions were: 1) what are the local hydrostatic stresses and tensile strains occurring within the multipotent mesenchymal tissue regenerate during mandibular DO; and, 2) do the patterns of hydrostatic stress and maximum principal tensile strain correspond to expected locations of bone regeneration, cartilage formation, and new mesenchymal tissue regeneration as we would predict with a mechanobiological tissue differentiation concept (Fig. 2)?

RESULTS: Hydrostatic Stresses. Hydrostatic stresses in all models were generally mild with the highest stress still below 1 MPa. The highest magnitudes of hydrostatic stress were tensile and usually occurred in the distraction gap with all models also exhibiting some periosteal tufts of hydrostatic pressure.

Maximum Principal Tensile Strains. Tensile strains varied greatly with the highest tensile strains experienced by the end latency specimen and the lowest by the distraction day 5 specimen. In general, strains were highest in the center of the distraction gap and greatly decreased closer to the osteotomy ends and outside the distraction gap.

Histological data. Histological analyses showed other specimens at the same time points exhibited mesenchymal tissue in the center of the distraction gap, bone formation at the osteotomy ends for distraction day 2, 5, and 8 specimens, and cartilage and bone formation periosteally.

RESULTS:

MECHANOBIOLOGY OF MANDIBULAR DISTRACTION OSTEOGENESIS – FINITE ELEMENT ANALYSES WITH A RAT MODEL

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