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NUMERICAL INVESTIGATIONS OF BONE REMODELLING AROUND THE MOUSE MANDIBULAR MOLAR PRIMORDIA

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Summary: Objective: Regeneration of the alveolar crests degrading over time, a common clinical finding in most human adults, has been a challenge in periodontal regenerative therapy for years. The challenge is not only the regeneration of the alveolar bone, but also its formation. The formation of the alveolar bone, which houses the dental primordia, and later the dental roots, may serve as a model to approach general questions of bone formation. This study aimed to investigate the interaction between the alveolar formation and tooth eruption and their biomechanical mechanism by studying bone remodelling around the mouse mandibular molar primordia.
Method: 38 heads of mice (C57 Bl/6J) ranging from stages E13–P20 were used to prepare histological serial sections. For each stage, 3D reconstructions were made to study the morphogenesis of the mandibular molar primordia concomitantly with their surrounding bone. 3D finite element models were generated from the 3D data of the specimens using the software Mimics and 3-Matic (Materialise, Leuven, Belgium). Cortical bone, spongious bone, dentin, enamel and dental follicle around the primordia were generated and converted into 3D FE models using 4-noded tetrahedral elements. Models were imported into the FE software package MSC.Marc/Mentat (MSC.software, Santa Ana, CA). Surface loads were applied to the surface of dental follicle ranging from 0.1cN to 10cN and the results were compared with the histological results.
Results and Discussion: The validity of the model was analysed by comparing the density pattern of the alveolar bone as determined in the histological study with the loading pattern from the numerical analysis. Maximum shear stresses (1.5 N/mm²) and strains (>300 με) as well as strain energy density (>0,5*10-3) were observed in exactly those regions were the histological study revealed highest remodelling activity with bone apposition. The numerical model showed that an eruptive force of 1 cN fits the continuously growing Molar Primordia, which was consistent with the results of animal experiments.