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Biomechanical Roles of Soft Tissues in Bone Remodeling

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Abstract:
Despite increasing understanding in the importance of genetic and biological cues to bone remodeling [1,2], mechanical loading is still a critical factor in modulating skeletal morphology. It remains unclear why tens of kilograms of weight are required for orthopaedic rehabilitation, whilst only tens to hundreds of grams force stimulates significant bone remodelling in orthodontic therapy. How could the bones in the same body purposely adapt to such three order difference in mechanical force? We propose soft connective fibrous tissues, such as periosteum, endosteum and periodontal ligament (PDL), around bone play an important role in sensing “transverse” tension and compression in a way different from “longitudinal” stimulation in intracortical tissue. Finite element (FE) based modeling and remodeling procedures are developed here to simulate how the connective soft tissues determine bone remodeling. Three different clinical cases in dental orthopaedics were explored in this study: (1) mucosa in bone resorption induced by different denture treatments [3]; (2) dental follicles in tooth eruption and jaw development [4]; (3) periodontal ligament (PDL) in orthodontic tooth movement [5]. It is found that hydrostatic stress signifies a key measure to abovementioned biomechanical role. If hydrostatic stress is higher than systolic pressure, delivery of nutrients and transport of metabolites may be jeopardised, affecting bone’s turnover and leading to bone resorption in the compression area.

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