Effort calculation occurring under orthodontic appliance action taking into account parodentium elasticity.

S. M. Bosiakov, K. S. Yurkevich, S.A. Yurkevich

Orthodontic treatment is one of components of the upper jaw anomalies elimination, which is realized maxillary expansion, displacements and rotations of the teeth. Therefore, when designing orthodontic arches and appliances the prediction of forces and moments of forces acting on the tooth is necessary. In the present paper the results of biomechanical modeling of orthodontic appliance with four crowns and screw are presented taking into account parodentium elasticity. Supporting system of the tooth (parodentium) includes a set of interconnected tissues that surround and fix the tooth. Since parodentium holds the tooth in the alveolar socket, distributing mastication load and adjusting the pressure during mastication, one of its main functions is to support and shock absorbing. This fact determines the necessity to consider the parodentium elasticity under calculation effort, developed by orthodontic appliances.

Forces and torques calculation acting from the direction of the rod at the tooth root was done on the basis of differential relationships between the lateral force, the moment of force and displacement of the rod. The functional dependence of the rod displacement from the coordinate which varying along the rod axis is obtained by solving the equation of rods' transverse bending. During equation solving the following boundary conditions are assumed: displacement of the upper rod end coincides with the distance which gets the rod under screw unwind, the rotation angle of the upper rod end is equal to zero, the lower rod end elastically fixed in parodentium. Parodentium stiffness at translational displacements in all directions was equal to 10 kN/m, bending stiffness of parodentium was equal to 1,5 N·m. After finding the forces and moments, developed by the orthodontic appliance rod, the dependences of the forces and moments in the oro-vestibular, mesio-distal and vertical directions from the angles defining the rod orientation were obtained. The calculations were done for the cases when the rod is in the horizontal and vertical planes, as well as in the parallelepiped diagonal plane whose edges pass through the coordinate axes. Geometrical and physical properties of the orthodontic appliance rod are corresponded to the real constructions of the appliances with HYRAX screw. The displacement of upper rod end is assumed equals to 1 mm. Obtained dependences shows that the highest values of concentrated forces produced by the appliance rod in it different positions are values 10-14 N, the maximum torques 0,025-0,035 N·m. At the same time it should take into account the moments of forces acting from the direction of the rod at the tooth root. It is important because of the low periodontal stiffness under root rotation. The effect of even small torques can lead to sufficiently large angles of rotation of the tooth relative to its initial position. This is especially important for bone stock atrophy, leading to a significant reduction of periodontal stiffness.

The analysis of the forces and moments of forces which was realized for different cross-section radius and length of the rods shows that with increasing radius and length of the rod forces and moments increase and decrease accordingly.