GEAR PROPERTIES OF THE HUMAN KNEE JOINT

U. Rehder

Orthopädische Universitätsklinik, Hamburg, Germany

1. INTRODUCTION

A twodimensional geometrical model of the knee joint based on the involute geometry of the femoral condyles was established. The calculated ligament length patterns were in good agreement with experimental data from a three-dimensional model (Zabel, Rehder, 1986). A twodimensional description is an adequate tool for explaining qualitatively the kinematics of the knee.

2. RESULTS

The profiles of the femoral condyles in the sagittal plane can be described by an involute of a circle within an accuracy of ± 0.2 mm (Rehder, 1983) (Fig.1). Consequently, the plane motion of the knee joint can be explained by investigation of the geometrical properties and the kinematical behavior of the involute.

The construction of the involute is performed by rolling a straight line on the base circle (Fig.2). The circle is the geometrical locus of the centers of curvature of the spiral. The length of the normal is proportional to the angle of evolution t.
During gliding motion, a fixed point on the tibial plateau comes into contact with the whole circumference of the femoral condyle. As derived from the construction of the involute, during flexion motion of the knee the base circle (the evolute of the femoral profile, in general) rolls on a straight line perpendicular to the tibial plateau (Fig.3). The base circle is the polhode of the body fixed system, the contact point defines the instant center of rotation.

Therefore, a point connected with the femur runs through a cycloid (Fig.3). The loop of the cycloid implies the existence of a maximum of distance between a point on the femur and a point on the tibia. A fiber attached to both of the bones is tightened, when it reaches its maximum of length at a particular angle of flexion (Fig.4). At this angle the fiber crosses the instant center of rotation, i.e. the contact point of the circle and the perpendicular line.