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Research paper

The role of mechanical stress on the formation of a curly pattern of human hair

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ARTICLE INFO

Article history:
Received 9 January 2010
Received in revised form
23 June 2010
Accepted 28 June 2010
Published online 4 July 2010

Keywords:
Human hair
Hair follicle
Curly pattern
Residual strain gradient
Finite element method (FEM)

ABSTRACT

Understanding the factors that contribute to the curly morphology of human hair is important for anthropological and physiological studies. In the present study, the possible role of mechanical stress on the formation and selection of such a curly pattern of hair is explored. Based on the model of hair curling upon being squeezed through pinched nails, it is found that different levels and configurations of external forces could lead to the variation of residual strains, which in turn, is related to the two-dimensional (2D) and three-dimensional (3D) spatial hair curvatures. The mechanical principles are readily applicable to hair curling geometry due to the growth force exerted by hair follicles. The key mechanical parameters controlling the formation of a curly pattern of hair, as well as the key geometrical shape factors characterizing the hair morphology, are identified and correlated. The results obtained from the mechanical model are qualitatively consistent with those of previous experiments and observations.

1. Introduction

The geometrical appearance of human hair is an important characteristic of ethnicity: for example, Asian, African, and Caucasoid humans are often distinguished by their straight, curly, and wavy hair features, respectively. Understanding the mechanism of the curly pattern of hair is a fundamental issue not only in anthropology, for example providing useful evidences on the evolution of different ethnic groups (Danforth, 1939; Loussouarn et al., 2007), but also in physiology, for example helping detect various hair diseases and exploring possible therapeutic approaches (McMichael, 2003; Peytavi et al., 2008).

Earlier studies observed that straight human hair often has a circular cross-section whereas curly human hair has an elliptical cross-section, and argued that the curly pattern was simply due to the geometrical shape of the hair shaft (Danforth, 1939; Garn, 1947). However, Hrdy found that the cross-section of the curliest hair was often not the most elliptical (Hrdy, 1973), which indicated other factors dominating hair curvature besides the geometrical relationship. A microstructural study based on transmission electron microscopy (TEM) of cross-sections of hair showed that the curling degree is related to the cell distribution within the hair cortex (Thibaut et al., 2007): the orthocorcortical cells dominate in curly hair whereas the mesocortical

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doi:10.1016/j.jmbbm.2010.06.009