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# Long Wavelength Approximation to Peristaltic Motion of Micropolar Fluid with Wall Effects

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**Abstract.** Peristaltic motion of an incompressible micropolar fluid in a two-dimensional channel with wall effects is studied. Assuming that the wave length of the peristaltic wave is large in comparison to the mean half width of the channel, a perturbation method of solution is obtained in terms of wall slope parameter, under dynamic boundary conditions. Closed form expressions are derived for the stream function and average velocity and the effects of pertinent parameters on these flow variables have been studied. It has been observed that the time average velocity increases numerically with micropolar parameter. Further, the time average velocity also increases with stiffness in the wall.

**AMS subject classifications**: 76Z05, 76A05.

**Key words**: Peristaltic motion, micropolar fluid, dynamic boundary conditions.

## 1 Introduction

The fluid mechanics of peristaltic motion has been extensively studied for several years as it is known to be one of the main mechanism for fluid transport in biological systems. From the point of view of fluid mechanics, peristaltic pumping is characterized by dynamic interaction of fluid flow with the movement of a flexible boundary. In fact peristalsis is the major mechanism for the transport of urine from kidney to bladder, food mixing in the intestines etc. It is also speculated that peristalsis is involved in the vasomotion of small blood vessels. Also mechanical devices like finger pumps and roller pumps use peristalsis to pump blood, slurries, corrosive fluids and so on.

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It is well-known that many physiological fluids behave in general like suspensions of deformable or rigid particles in a Newtonian fluid. Blood, for example, is a suspension of red cells, white cells and platelets in plasma. Another example is cervical mucus, which is a suspension of macromolecules in a water-like liquid. Several investigators have tried to account for the suspension behaviour of biofluids by considering them to be non-Newtonian.

The model of micropolar fluid introduced by Eringen [1] represents a fluid consisting of rigid, randomly oriented (or spherical) particles suspended in a viscous medium where the deformations of the particles are ignored. The main advantage of using micropolar fluid model compared to other non-Newtonian fluids is that it takes care of the rotation of fluid particles by means of an independent kinematic vector called the microrotation vector.

Several authors [2–5] have studied peristaltic transport of a Newtonian fluid in both mechanical and physiological situations under different conditions. Further, peristaltic motion of non-Newtonian fluids also received attention. Shukla et al. [6] studied effect of peristaltic and longitudinal wave motion of the channel wall on movement of microorganisms. Srinivasacharya et al. [7] considered peristaltic transport of a micropolar fluid in a circular tube under low Reynolds number and long wave length approximation. Maruthi Prasad and Radhakrishnamacharya [8] discussed peristaltic transport of a Herschel-Bulkley fluid in a channel in the presence of magnetic field of low intensity. However, all these investigations did not take the wall effects into consideration. Mittra and Prasad [9] considered peristaltic transport in a two-dimensional channel considering the elasticity of the walls. They used dynamic boundary conditions and solved this problem under the approximation of small amplitude ratio. Radhakrishnamacharya and Srinivasulu [10] studied the same problem under long wave length approximation. Muthu et al. [11] extended the analysis of Mittra and Prasad [9] to micropolar fluids. However, no attempt has been made to study the influence of wall properties on peristaltic transport of a micropolar fluid using the dynamic boundary conditions under long wave length approximation.

Hence in the present study, the influence of wall effects on the peristaltic motion of a micropolar fluid in a two-dimensional channel using the dynamic boundary conditions is investigated. Perturbation method of solution has been obtained in terms of wall slope parameter assuming that the wave length of the peristaltic wave is large in comparison to the mean half width of the channel. Expressions for the stream function and average velocity have been derived and the effects of various parameters on these flow variables have been studied.

## 2 Formulation of the problem

We consider the flow of an unsteady incompressible micropolar fluid through a two dimensional channel of width $2d$ and with flexible walls on which are imposed traveling sinusoidal waves of long wave length. Cartesian coordinate system $(x, y)$ is chosen with the $x$-axis aligned with the centre line of the channel. The traveling waves are rep-