Computer Methods in Biomechanics and Biomedical Engineering
Vol. 15, No. 2, February 2012, 195–201

Simulation and study of the geometric parameters in the inguinal area and the genesis of inguinal hernias

Gerard Fortuny[a]*, Manuel López-Cano[b], Antonio Susín[c] and Blas Herrera[a]

[a]*Departament d'Enginyeria Informàtica i Matemàtiques, Universitat Rovira i Virgili, Reus, Spain;* [b]*Department de Cirurgia, Hospital General Universitari Vall d'Hebron, Universitat Autònoma de Catalunya, Barcelona, Spain;* [c]*Departament de Matemàtica Aplicada I, Universitat Politècnica de Catalunya, Barcelona, Spain*

(*Received 24 February 2009; final version received 6 September 2010*)

We are interested in studying the genesis of a very common pathology: the human inguinal hernia. How the human inguinal hernia appears is not definitively clear, but it is accepted that it is caused by a combination of mechanical and biochemical alterations, and that muscular simulation plays an important role in this. This study proposes a model to explain how some physical parameters affect the ability to simulate the region dynamically and how these parameters are involved in generating inguinal hernias. We are particularly interested in understanding the mechanical alterations in the inguinal region because little is known about them or how they behave dynamically. Our model corroborates the most important theories regarding the generation of inguinal hernias and is an initial approach to numerically evaluating this affection.

Keywords: finite element method; simulation; inguinal hernia; muscular contraction

Introduction

Hessert's triangle (Keith 1924; Abdalla and Millelstaedt 2001) is in the suprainguinal space of the myopectineal orifice. Its apex is the internal inguinal ring, its sides are the internal oblique and transversus abdominis muscles and the inguinal ligament, and its base is the edge of the rectus abdominis muscle. The base is also covered by the fascia transversalis. The fascia transversalis, along with the internal inguinal orifice, is a weak zone through which a hernia can be produced, although in vast majority of individuals hernias do not develop in this area. Little is known about the real functional characteristics, dynamics or clinical repercussions of inguinal hernias because data have usually been obtained from static studies mostly performed on human cadavers (Ajmani and Ajmani 1983; Abdalla and Mittelstaedt 2001).

This study will be useful for simulating the deformational behaviour of non-rigid structures and applying this knowledge to surgical simulations. Computer-based simulation models may help us to better understand the dynamic behaviour and functioning of these defence mechanisms against hernia formation, and, indeed, models illustrating muscle–tendon mechanics in different structures have already been developed (Zajac 1989; Teran et al. 2005).

We describe here a dynamic simulation model of the internal oblique muscle and the internal inguinal ring in Hessert's triangle. To do this, we use the classic Hill–Maxwell rheological model to assess the behaviour of the inguinal 'shutter' mechanism. We have also examined simulations of how the internal oblique muscle responds to several parameters and external forces.

Previous considerations

To study the dynamics of the region, we have simulated the oblique internal muscle because this is the most important dynamic element (Keith 1924; Ajmani and Ajmani 1983; Abdalla and Mittelstaedt 2001), especially given its position in Hessert's triangle (Abdalla and Mittelstaedt 2001). The triangle's vertex is the inguinal internal orifice; its sides are the oblique internal muscle with the aponeurotic arch of the transverse muscle and the inguinal ligament and their base is the aponeurotic edge of the straight muscle (Figure 1). The anatomy of inguinal area is composed of the dynamically active elements (the oblique internal muscle and the transverse muscle) and the dynamically passive elements (ligaments, fascias and aponeurotic tissue). In this area, the oblique internal muscle and the inguinal ligament are fixed to the pubis tubercle and the hip bone. The transverse muscle begins in the tubercle pubis and ends in the thoracic box. The medial inguinal hernia takes place when an internal organ emerges through the Hessert's triangle breaking the transversalis fascia. In the Hessert's triangle, the unique active element is the internal oblique muscle at this level the transverse muscle is composed of aponeurotic tissue (Martinez 2001; Peiper et al. 2004) (Figure 2). We may consider the side of the

*Corresponding author. Email: gerard.fortuny@urv.cat

ISSN 1025-5842 print/ISSN 1476-8259 online

http://dx.doi.org/10.1080/10255842.2010.522182
http://www.tandfonline.com