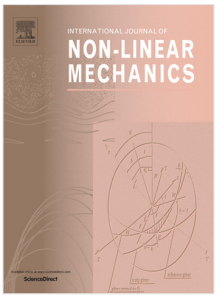
Accepted Manuscript



Edge effects in elastic bulging

Félix Benoist, Finn Box, Alain Goriely

PII: S0020-7462(18)30190-2
DOI: https://doi.org/10.1016/j.ijnonlinmec.2018.07.004
Reference: NLM 3051

To appear in: *International Journal of Non-Linear Mechanics*

Received date : 26 March 2018
Revised date : 21 May 2018
Accepted date : 9 July 2018

Please cite this article as: F. Benoist, F. Box, A. Goriely, Edge effects in elastic bulging, *International Journal of Non-Linear Mechanics* (2018), https://doi.org/10.1016/j.ijnonlinmec.2018.07.004

Edge effects in elastic bulging

Félix Benoist, Finn Box, Alain Goriely
Mathematical Institute, University of Oxford

Corresponding author: goriely@maths.ox.ac.uk

July 21, 2018

Abstract

Elastic bulging occurs when an elastic material deforms through a small opening in a rigid boundary. This problem is complementary to the indentation problem where displacement is applied to a small part of an elastic material. Understanding bulging is crucial in a number of applications related to swelling such as the deformation of the brain following a decompressive craniectomy. In particular, it is known that large stresses develop close to the opening leading to potential material damage. To alleviate this problem, it is conceivable to modify the shape of the edge to reduce stress increases. Here, we study edge effects during planar bulging and show how an opening should be shaped to remove stress singularities.

1 Introduction

After a traumatic brain injury, intracranial pressure may increase [1] and create long lasting brain damage unless it is quickly reduced. If the intracranial pressure remains too large for an extended period of time, a routine, but highly invasive, treatment is *decompressive craniectomy* [2] where part of the skull is surgically removed [3] to allow the brain to swell uninhibitedly, thereby relieving pressure [4, 5, 6, 7]. This operation is controversial because it creates potential axonal damage and local tissue damage near the skull opening [8, 9].

A potential solution to reduce stress build-up at the opening is to insert a toric joint between the skull and the brain, which has the consequence of curving the edge and the elastic material [10]. We investigate the mechanical consequences of the implementation of a toric joint by examining bulging through an opening and the effect of the opening edges on the stress and strain inside a bulging elastic material.

Whereas indentation is the deformation of an elastic material due to the displacement of a small part of its boundary, bulging is the deformation of an elastic material through the opening of a rigid boundary. Unlike the case of indentation that has been studied extensively [11], bulging has received little attention in the literature and was only recently introduced as a generic problem motivated by medical concerns [12].

Here, we consider the bulging of a (linearly) elastic half-plane. For small deformations and in a planar geometry, the exact solution is derived from the theory of contact mechanics and we can explicitly study the deformations resulting from a sharp-edge and a curved-edge opening.