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NUMERICAL STUDY ON THE DEFORMATION OF THE PELVIC FLOOR MUSCLES DURING A VAGINAL DELIVERY

Hypothesis / aims of study

Pelvic floor dysfunction is a hidden problem with a magnitude unknown to many. Statistics show that 1 in every 10 women will have pelvic floor dysfunction so severe that it will require surgery [1]. Several studies have shown that pelvic floor injuries during a vaginal delivery can be considered a significant factor in the development of urinary incontinence, fecal incontinence and pelvic organ prolapse. The objective of the present work is to contribute to the clarification of the mechanisms behind pelvic floor disorders related to a vaginal delivery. For this purpose a numerical simulation based on the Finite Element Method was carried out. The Finite Element Model intends to represent the effects that the passage of a fetal head can induce on the muscles of the pelvic floor, from a mechanical point of view. The model used for the simulation represents the pelvic bones, with the attached pelvic floor muscles and the fetus.

Study design, materials and methods

The Finite Element Model used in this work was constructed using the geometrical point data obtained from cadaver measurements. All the measurements were performed on one embalmed 72 year old female cadaver obtained for scientific research. The specimen was selected for having no pathology to the pelvic floor. The cause of death was unknown and presumably not affecting the pelvic floor musculature [2]. The principal obstetric dimensions for the fetal head are the following: Suboccipito-bregmatic diameter, 10 cm, Suboccipito-frontal diameter, 10.5 cm, Occipito-frontal diameter, 12.0 cm, Mento-vertical diameter, 13.0 cm and Submento-bregmatic diameter, 11.5 cm. The dimensions of the fetal head are in accordance with the literature. The simulation was performed using the implicit version of the commercial software ABAQUS. In this work the movements of the fetus during birth, in the vertex position were simulated, namely, the engagement, descent, flexion, internal rotation and extension of the fetal head. To evaluate the maximum muscular deformation, several levels along the pelvic floor muscles were defined, as shown in Figure 1. This model as also been successfully used to study the effect of malposition, such as occipitoposterior position, on the degree of muscle deformation during delivery.

Results

Results for the pelvic floor deformation values, obtained during the passage of the fetus head are presented. The maximum deformation obtained was 0.66 for a vertical displacement of the fetal head of approximately 60 mm. In order to present a better comparison of the obtained results, for all levels, only one scale varying between 0 and 1 was considered, called normalized length. For example, 0 represents one of the extremities, 0.5 represents the middle position and 1 represents the position in the opposite extremity (Figure 1). On Figure 2 the evolution of the deformation along the different levels (normalized lengths), for a vertical displacements of the fetal head of 60mm is shown. The deformation - E1 is defined as the ratio between the variation in length and the original tissue length. The deformation values are calculated for each finite element cell, along the different levels. Proceeding in this fashion, we can show the location along the different curves where the deformations are higher. A close observation of the evolution of the deformations along level 1 shows that we obtain high values of deformation on the edges of level 1 which correspond to the points of attachment of levator ani muscle and the pubococcygeus muscle to the pelvic bones. The maximum values for the deformation appear in an area that corresponds to the middle length of the levator ani muscle and the pubococcygeus muscle

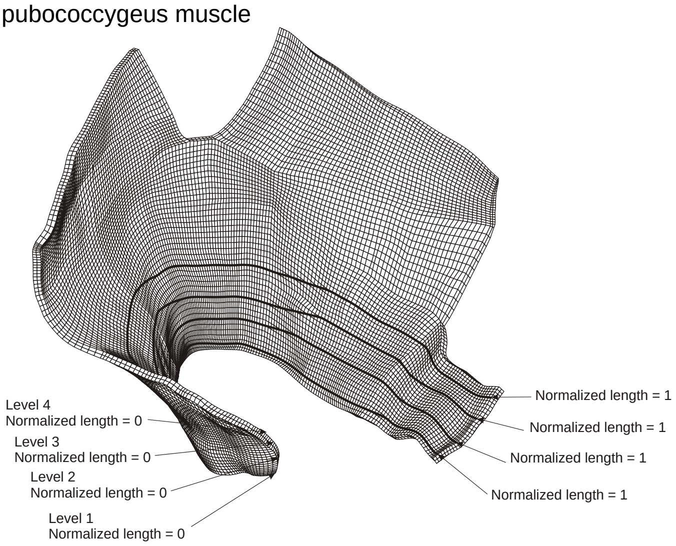

Fig. 1- Levels used.

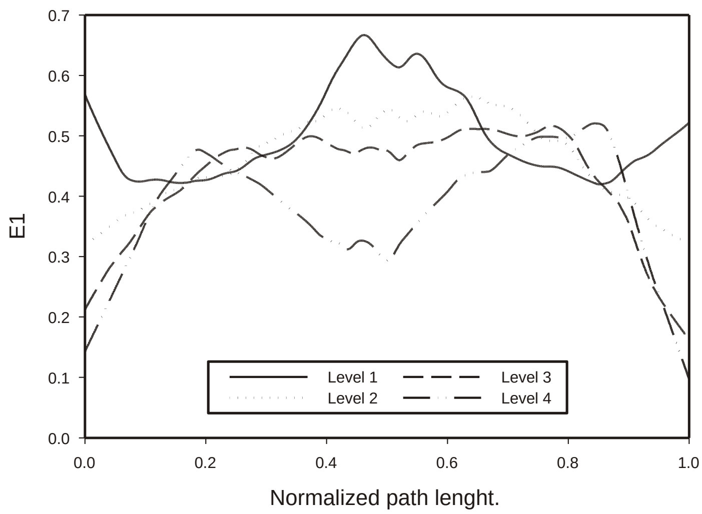

Fig. 2 – Deformations obtained.

Interpretation of results

The maximum muscle deformation of 0.66 found in this study exceeds this largest non-injurious deformation presented in [3]. If injury can be caused by fiber deformation exceeding a maximum permissible value, we may conclude that a risk exists for injury of the muscles of the pelvic floor during the second stage of labor. The problem studied here is very complex, and any methodology used will be prone to have limitations and to criticism. In order to properly interpret our findings, we need to consider the limitations involved. Some limitations are the lack of additional information about the data used. The non consideration of time dependent material properties (although this will not affect the deformations obtained). The occurring of moulding of the fetal head during delivery. A multitude of variables such as variations in maternal pelvic shape, fetal head shape, the degree of moulding during delivery, symphyseal diastasis, types of episiotomies, and presenting orientation may affect the maximum muscle deformations, thus affecting the final results.

Concluding message

As investigation progresses, clinicians will eventually shift from a condition-based approach to an injury-based approach, radically transforming both clinical research and patient care. An enhanced precision in defining pelvic floor disorders will revolutionize our ability to define and implement appropriate treatment, as well as to conduct focused clinical research. The computer model presented in this work is a first step in understanding how obstetrical factors and interventions might influence levator ani injury risk, since experimental measurements of levator stretch in laboring women are not currently feasible for many clinical, technical and ethical reasons. The present numerical simulation shows that the muscles of the pelvic floor are submitted to high deformations during the passage of the fetus head. During a vaginal delivery, the elevator ani muscle and the pubococcygeus muscle are the muscles that are subjected to the largest values of stretch and strain. These muscles are the ones at greater risk for a stretch related injury. The present work showed a non-invasive procedure which can be used in the future to estimate the damage that a vaginal delivery can induce on a specific pelvic floor.

References

1. Obstet Gynecol (1997) 89; 501-506.
2. Int Urogynecol J (2007) 19; 65-71.
3. Obstet Gynecol (2004) 103; 31-40.

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Is this a clinical trial?	**No**
What were the subjects in the study?	**HUMAN**
Was this study approved by an ethics committee?	**No**
This study did not require eithics committee approval because	**This is a numerical study.**
Was the Declaration of Helsinki followed?	**Yes**
Was informed consent obtained from the patients?	**No**