528

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EFFECTS OF PUBORECTALIS MUSCLE CONTRACTIONS ON THE RESULTING ANORECTAL ANGLES: A COMPUTATIONAL MODELLING STUDY

Hypothesis / aims of study

The puborectalis muscle (PRM) plays a vital role in the maintenance of fecal continence. Contraction of the PRM decreases the anorectal angle (ARA), thus maintaining gross continence. Computational modelling provides a convenient and non-invasive tool to investigate the continence mechanism of anorectal muscles. However, most current computer models do not consider the impact of active muscle contraction and, as a result, their accuracy is compromised. This study aims to develop a computational model of the female pelvic floor and anorectal muscles during active PRM contraction. The model was used to simulate the effect of varying PRM contractile forces on the magnitude of the ARA.

Study design, materials and methods

A computational model was developed from high-resolution MR images of a healthy 21-year old female subject. Image segmentations were performed for 6 anatomical parts inside the pelvis and 3D closed surfaces were reconstructed for each part. After surface smoothing, all parts were imported into ABAQUS 6.12 (SIMULIA, Providence, RI) and meshed into tetrahedral elements. All parts were assigned linear elastic material models from the literature. Figure 1(a) shows the finite element model with simulation conditions. Contraction of the PRM was realized with concentrated forces applied to the origin of the muscle. A dynamic pressure increasing from 0 cmH_2O to 50cmH_2O was applied to the antero-superior surfaces of the bladder and rectum to represent the intra-abdominal pressure (IAP) during a Valsalva manoeuvre [1]. The ARA was defined as the angle between the posterior anal canal and the posterior rectal wall. Two tests were performed. Test 1 served as the normal squeezing state with a contraction force of 8 N which is close to a normal contraction force of the levator ani muscle [2]. In test 2, the contractile force was weakened to 2 N. The dynamic ARA response was monitored.

Results

Figure 1(b) and (c) show rectal deformations in the mid-sagittal view at full contraction for both tests. Resting ARA was 119.9°. In test 1, a contractile force of 8 N resulted in a 20.6° change in ARA from rest to squeeze. Upon weakening, the change in ARA from rest to squeeze was reduced to 11.8°. Figure 2 shows the evolution of the ARA with the simulation time in response to the combinational effects of the increased IAP and the contraction force.

Interpretation of results

The marked decrease observed in ARA, caused by a lower contraction force of the PRM highlights the role of this muscle in maintaining continence. The quantification of ARA changes according to the varying PRM contraction forces provides useful information for investigating the functional property of PRM and its role in maintaining fecal continence. Future work includes a validation against dynamic MR images taken from the same subject, and on that basis, to model and optimize emerging treatment approaches for FI, such as puborectalis sling implantation.

Concluding message

In this study we developed a computational model of the pelvic floor which included the role of active contraction of the PRM. This study represents the first active computational model to investigate the mechanism of the anorectal muscles in maintaining fecal continence. This novel approach is expected to assist in personalized treatment as well as the design of implantable devices for fecal incontinence.

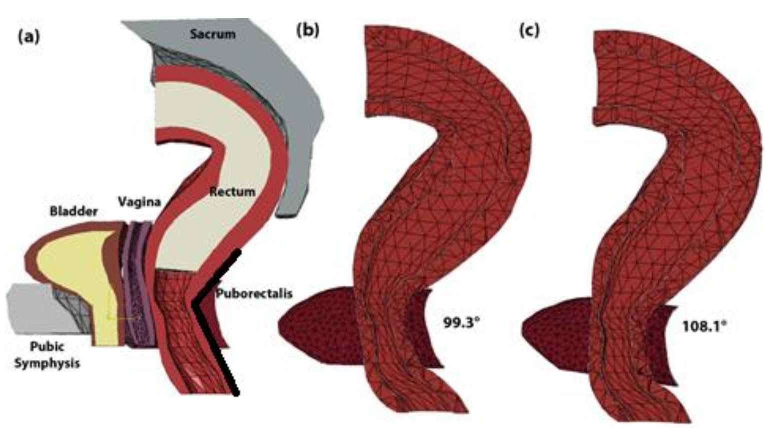

Figure 1 (a) Mid-sagittal view of the pelvic model, (b) anorectal angle under normal contraction and (c) anorectal angle under impaired contraction.

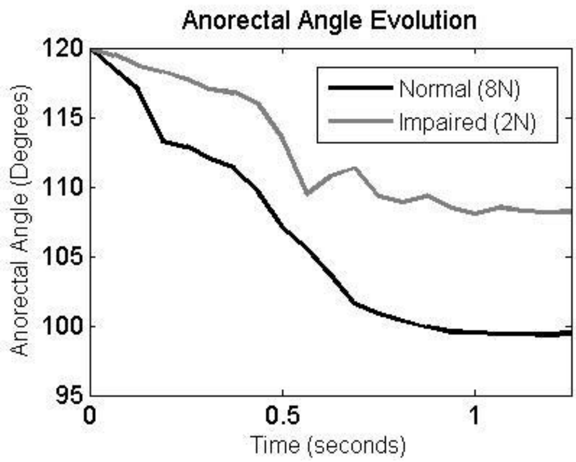

Figure 2 Anorectal angle evolutions during both impaired and normal tests.

References
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Disclosures

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