A finite element investigation of the positioning of Arabin® cerclage pessary in the prevention of spontaneous preterm birth

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1. Introduction

Spontaneous preterm birth (SPTB) is strongly associated with cervical funnelling. The condition is multifactorial and leads to global peri and neonatal mortality and morbidity [1,2], with the less developed countries being most affected due to a lack of management strategies. There exist a few treatment options for SPTB, including cervical cerclage [4], hormonal therapy using progesterone, and Arabin® cerclage pessary [3]. The Arabin® cerclage pessary has been widely used due to its low cost and ease of insertion. However, the mechanical interaction between the cervix and the pessary is not well understood [5]. Therefore, the aim of this study is to conduct preliminary investigation into: (a) the mechanical effect of the pessary on reducing cervix funelling, and (b) the effect of various pessary positions on supporting the cervix.

Methods

MRI data were provided by Cannie *et al.* [6] for two pregnant women with cervical incompetence. Scans were obtained at gestational weeks 26, 29 and 33. In week 26, both women underwent a procedure for the insertion of the Arabin® pessary, and scans were taken before and after the procedure. Finite element models of the uterine cervix were created based on these MRI scans (before pessary insertion). The 3D model of the Arabin® pessary was provided by Dr. Arabin GmbH & Co. The pessary device was modelled using medical grade silicone, with Young's Modulus of 25.5MPa and Poisson's ratio of 0.48. The uterine cervix tissue was modelled using a Neo-Hookean hyperelastic model with a shear modulus of 1.9kPa [7]. The interaction between the pessary and the cervix was defined as rigid contact. Fixed displacement boundary conditions were defined in all directions at the bottom of the cervix and horizontally at the top of the uterus. Various pressure values were applied to the nodes in the area of internal os in order to represent the intrauterine pressure at the corresponding gestational stages [5, 8]. The simulations were carried out in ANSYS APDL 16.1. The deformed finite element mesh of the cervix (after pessary insertion) was qualitatively compared with the MR scans in order to confirm the predicted results. The models were then used to simulate various pessary positions and their effects on supporting the cervix (see Figure 1).

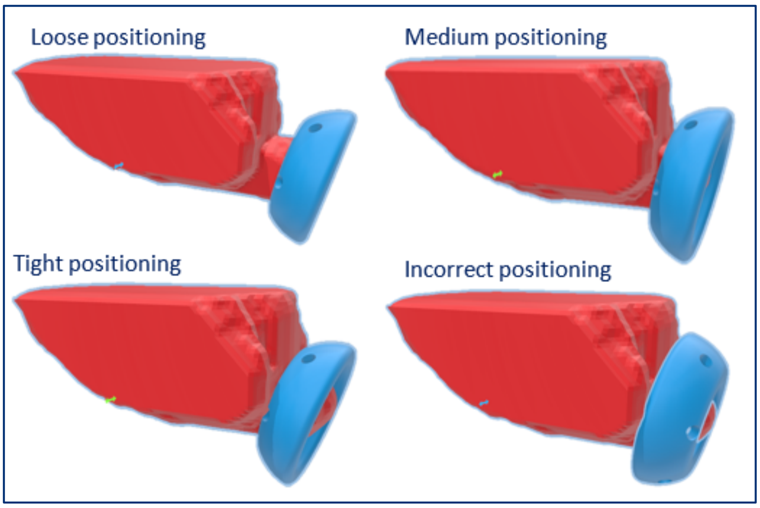

Figure 1 *The four different positions simulated with the pessary device: loose, medium, tight positions and incorrect position with an upside down pessary.*

Results

The model with pessary insertion was able to predict a similar effect as seen on the MR scan where the pessary lifts the cervix upwards towards the posterior, providing support to the structure and narrowing the funnelling. Loose, medium and tight positioning all provided some support to the cervix, with the loose positioning predicted to be the most effective in reducing funnelling and achieving a more even distribution of stretch. However, when an upside down pessary was simulated (as mistakenly indicated by some journal covers), the device seemed to have increased the amount of stretch in the cervix that could exacerbate funnelling (Figure 2).

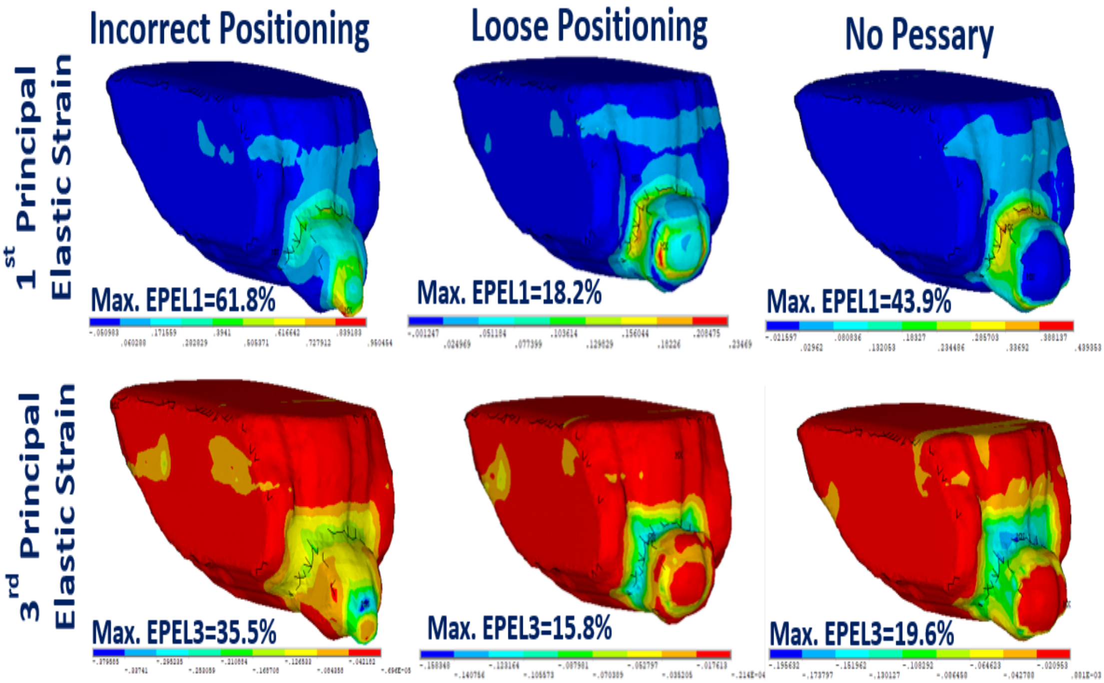

Figure 2 *The four different positions simulated with the pessary device: loose, medium, tight positions and incorrect position with an upside down pessary. The patient geometry was based on MR scans taken at 26 week of gestation.*

Conclusions

Preliminary results shown that finite element models were able to correctly predict the supporting effect of the pessary device after insertion into the cervix. All correct positions (whether loose or tight) would help reduce cervical funnelling to some extent. On the other hand, an upside down pessary had adverse effect on cervical support and should be avoided.

References

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