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The role of thumb and index finger placement in manual perineal protection

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Abstract

Introduction and hypothesis Comparison of the modifications of the Viennese method of manual perineal protection (VMPP) and hands-off delivery techniques by applying basic principles of mechanics with assessments of tensions within perineal structures using a novel biomechanical model of the perineum. Evaluation of the role of the precise placements of the accoucheur's posterior (dominant) thumb and index finger in perineal tissue tension when performing a modified Viennese method of MPP.
Methods We carried out an experimental study on a biomechanical model of the perineum at NTIS (New Technologies for Information Society, Pilsen, Czech Republic). Hands-off and 38 variations of VMPP were simulated during vaginal delivery with the finite element model imitating a clinical lithotomy position.
Results The main outcome measures were quantity and extent of strain/tension throughout the perineal body during vaginal delivery. Stress distribution between modifications of VMPP showed a wide variation in peak perineal tension from 72 to 102 % compared with 100 % for the "hands-off" technique. Extent of reduction depended on the extent of finger movement across a horizontal, transverse x-axis, and on final finger position on a vertical, antero-posterior y-axis. The most effective modification of VMPP was initial position of fingers 12 cm apart (x=±6) on the x-axis, 2 cm anteriorly from the posterior fourchette (y=+2) on the y-axis with 1cm movement of both finger and thumb toward the midline on the x-axis ($\Delta x=1$) with no movement on the y-axis ($\Delta y=0$).
Conclusions In a biomechanical assessment with simulation of vaginal delivery, exact placement of fingertips on the perineal skin, together with their co-ordinated movement, plays an important role in the extent of reduction of perineal tension.

Keywords Manual perineal protection · Hands-on · Hands-off · Modeling · Perineal tension · Perineal strain

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Introduction

Obstetrical anal sphincter injuries (OASIS) may have serious short- and long-term consequences such as perineal pain and/or defecatory disorders. Despite a recent and dramatic rise in the incidence of OASIS [1] little has been done to implement any preventive steps to reverse this trend.

Manual perineal protection (MPP) during the final phase of the second stage of vaginal delivery has historically been one of the most frequently considered interventions for protecting the perineum. However, it has only rarely been investigated in recent years. In the past, a variety of techniques for MPP were proposed in relation to the pelvic anatomy and fetal head trajectory during vaginal delivery. The anterior (non-dominant) hand may assist either in the flexion or possibly the extension of the fetal head during the crowning of the perineum [2–4] or may just be used to slow the passage of the fetal head through the perineal structures without any additional flexion or extension. To answer the question regarding the substantial range of deformation to the perineum during the final phase of vaginal delivery, suggestions for the posterior (dominant) hand of the accoucheur [2] have included

palmar support executed in the midline [3], the Viennese method with fingertips alongside the vaginal introitus [2–4], or the Ritgen maneuver [5].

It is still difficult to prove the clinical significance of MPP. Previous randomized clinical studies [6, 7] have not found MPP to be beneficial in its effect on the range and/or degree of perineal trauma. In spite of the fact that a significant reduction in pain was observed in the group undergoing MPP [6], owing to the poor effect of MPP regarding the OASIS rate demonstrated in these studies [6, 7], neither the current evidence-based guidelines [8–10] nor the reviews [11] recommend the routine use of MPP for every vaginal delivery.

In the methods of these clinical studies [6, 7] the definitions of the terms "hands-on," "hands-off," and "perineal support" applied to non-identical interventions that differed from study to study [11] since a complete and precise description of the execution MPP was lacking [2, 4, 11]. Also, there was no adequate control of the exact execution of MPP, nor was any evaluation made of the real range of perineal trauma [2, 4].

Manual perineal protection (MPP) has also been put forward as a protective factor for OASIS [12–17]. In a retrospective study, it represented the only obstetric variable that differed significantly between two countries that exercise similar perinatal care while displaying remarkably different OASIS rates [12]. Other studies [13–17], incorporating a set of various modified interventions, led to significant decreases in OASIS. Therefore, the exact role played by MPP alone was difficult to assess.

Recently, simulation of the vaginal delivery of a spherical head using a novel biomechanical model both with and without MPP has shown that a part of this complex obstetrical intervention, the Viennese method (VMPP), markedly reduced the perineal tension throughout the full thickness of the perineum [2]. Two modifications of VMPP were compared with the hands-off approach resulting in a reduction in perineal tension of 39 % and 30 % respectively [2].

The aim of this study was to evaluate which specific location of the fingers on the perineum, together with co-ordinated movements between them, might achieve the maximum reduction in perineal tension with a view to minimizing perineal trauma.

A finite element biomechanical model [2] was used to analyze and compare the tension of the perineum during vaginal delivery for 38 different modifications of VMPP and the hands-off technique. This study was the third part of a larger project: PEERS 5P's (Perineal Trauma Prevention, Evaluation, Education and Recognition Study Group: Perineal Protection Program incorporating the Principles of Physics).

Materials and methods

The finite element model designed in a previous study [2], based on data from previous experimental, clinical, and biomechanical studies, and female pelvic floor geometry during the second stage of labor [4, 18–27], was used in this study for the simulation of the passage and expulsion of the fetal head during vaginal delivery.

A quasi-incompressible, transversely isotropic hyperelastic Mooney–Rivlin material model for the soft tissue was used in this study. The material and its parameters were described in a previous study [2].

The model geometry and the computational mesh were generated using a HyperMesh software package (Altair, Troy, MI, USA).

For the development of the numerical model of the realistic molded fetal head, a comparison was made between the dimensions resulting from the MR imaging of the full-term neonatal skull and from the CT scan of a real neonatal skull borrowed from the Department of Anatomy. To obtain dimensions and shapes for the molded fetal skulls, the widths of the skull sutures were subtracted and the final skull dimensions compared with the plastic molded model of the neonatal skull (Educational and Scientific Products, Rustington, UK). As the differences in the dimensions of the three skulls were insignificant and considering that it was easy to handle, the plastic molded model of the fetal skull was used for further development of the numerical finite element model (Fig. 1).

The trajectory of the passage of the fetal head through the birth canal followed the curve of Carus. The simulations were performed using Pam-Crash software [28]. Defining the exact timing of VMPP was achieved with the aid of experimental stereophotogrammetric measurements [2]. MPP was initiated when the dimensions of the vaginal introitus were 7 cm antero-posteriorly and 5.3 cm transversely [2]. The referential points for defining an exact location for the application of the finger (the tip of the distal phalanx) on the perineum were the anterior foci of the elliptic imprints of the fingertips (Fig. 2).

Calculation of the exact location (x, y) of finger application to the perineum was made using the referential point (0, 0) at the posterior fourchette (Fig 2). An axial plane of the perineal structures and fetal head was used for defining the x- and y-axes. These axes were defined as horizontal and vertical lines crossing the referential point. The co-ordinated movement between thumb and index-finger was performed along these axes (Δx, Δy).

The finite number of applications for each of four variables (x, y, Δx, Δy) was chosen regarding the real range of the deformation of the perineal structures, the anthropometric characteristics of the human hand, and the limits of the clinical precision of this intervention. The initial placement of the thumb and the index finger (x, y) was: 12 (−6, +6), 11 (−5.5, +5.5) or 10 (−5, +5) cm apart on the x-axis and at +3, +2, +1, 0, −1, −2 or −3 cm on the y-axis. The movement of each of the virtual fingers on the perineal skin (Δx, Δy) was 1, 0.5 or 0 cm medially from each side (on the x-axis) and 2, 1 or 0 cm posteriorly (on the y-axis). For example, in simulation 1, the

Fig. 1 Finite element model of the realistic molded fetal head
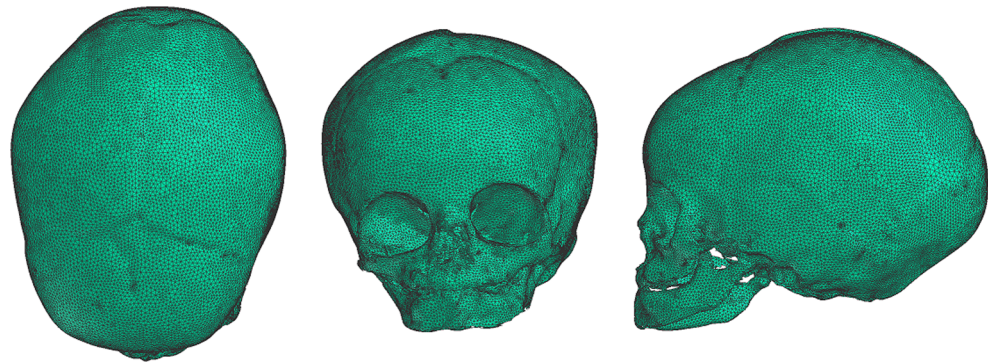
initial position of the thumb was on the right side 6 cm from the midline and 3 cm anteriorly of the level of the fourchette, while the initial position of the index finger was on the left side 6 cm from the midline and 3 cm anteriorly of the level of the fourchette (x=±6, y=+3). The movement of the finger tips (the movement of the tip of the distal phalanx) was 1 cm medially on both sides and 2 cm posteriorly (Δx=1, Δy=2), making the final position of the thumb 5 cm to the right of the midline and 1 cm anteriorly of the level of the fourchette, and for the index finger 5 cm left of the midline and 1 cm anteriorly of the level of the fourchette (x=±5, y=+1; Table 1).

The maximum perineal tissue tension and the size of the area of high tension (defined as an area of the perineal body on the cross-section through the mid-sagittal plane where the increment of perineal tension exceeded 20 % of the maximum tension achieved during the "hands-off" simulation) measured during the simulated expulsion of the fetal head (Fig 3) were compared with "hands-off," i.e., where no MPP was used.

The stretching and movements of the perineal tissue around the fetal head were recorded for all modifications of VMPP
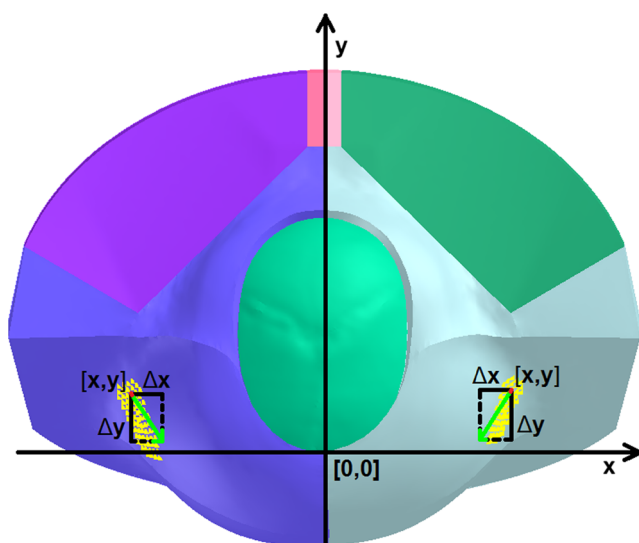
and "hands-off" techniques during a video simulation. The measurements were performed at the time of the passage of the suboccipito-bregmatic circumference through the vaginal introitus. A colored scale was used for digital visualization of the relative perineal tension, whereby 100 % corresponds to the maximum stress in the "hands-off" technique (Fig. 3).

Results

The stress distribution between modifications of VMPP simulated in the tests showed a wide variation in the peak tension between 72.1 and 102.1 % compared with the "hands-off" technique. In a majority of modifications of VMPP some degree of reduction in the maximum perineal tension was achieved (Table 1). The extent of this reduction depended on the modification used, i.e., on the extent of the movement of the fingers along the x-axis and on the final finger position on the y-axis (Table 1). On the cross-section of the stretched perineum there is a considerable decrease in the area of high tension throughout the perineal body in simulations performed with VMPP (e.g., hands-off and simulations 7 and 11, see Fig 3). With no modification of VMPP made on the cross-section, the area of high tension was larger than when the "hands-off" technique was used.

In the most effective modification of VMPP (simulation 7), the initial position of the fingertips was 12 cm apart (x=±6) on the x-axis and 2 cm anteriorly from the posterior fourchette (y=+2) on the y-axis with 1cm movement of both finger and thumb toward the midline on the x-axis (Δx=1) and no movement on the y-axis (Δy=0).

The following comparisons illustrate the importance of precision in the execution of such a complex procedure as MPP.

The placement of fingers and their movement along the y-axis

Identical initial position, different final positions on the y-axis

When simulations 5, 6, and 7 were compared, the only difference between them in this regard was the change in the finger's

Fig. 2 Calculation of the exact placement (x, y) of the fingers on the perineum together with their subsequent movement (Δx, Δy)

Table 1 Initial and final thumb and index finger placement on the perineum, their co-ordination, and the relative perineal tension achieved

Model	Initial placement (x-axis)	Initial placement (y-axis)	Transverse movement (Δx)	Antero-posterior movement (Δy)	Maximum perineal tension (%)	Area of increment of perineal tension >20 % (%)
0	Hands off				100.0	20.4
1	12 (−6; +6)	3	1	2	90.5	12.3
2	12 (−6; +6)	3	1	1	76.9	9.5
3	12 (−6; +6)	3	0.5	2	101.1	17.4
4	12 (−6; +6)	3	0.5	1	92.6	14.2
5	12 (−6; +6)	2	1	2	97.4	12.8
6	12 (−6; +6)	2	1	1	88.4	12.3
7	12 (−6; +6)	2	1	0	72.1	8.9
8	12 (−6; +6)	2	0.5	2	100.5	18.9
9	12 (−6; +6)	2	0.5	1	93.7	16.1
10	12 (−6; +6)	2	0	2	102.1	20.0
11	12 (−6; +6)	2	0	1	101.1	19.3
12	12 (−6; +6)	1	1	1	97.4	13.7
13	12 (−6; +6)	1	0.5	1	98.4	19.2
14	12 (−6; +6)	1	1	0	90	12.6
15	12 (−6; +6)	1	0.5	0	91.6	19.4
16	12 (−6; +6)	0	1	0	93.7	13.2
17	12 (−6; +6)	0	0.5	0	97.9	19.4
18	11 (−5.5; +5.5)	3	0.5	2	96,.3	12.4
19	11 (−5.5; +5.5)	3	0.5	1	81.1	13.1
20	11 (−5.5; +5.5)	2	0.5	2	86.9	19.0
21	11 (−5.5; +5.5)	2	0.5	1	88.4	12.5
22	11 (−5.5; +5.5)	2	0.5	0	77.9	12.8
23	11 (−5.5; +5.5)	2	0	1	99.5	19.2
24	11 (−5.5; +5.5)	1	0.5	1	95.8	17.3
25	11 (−5.5; +5.5)	1	0.5	0	85.8	12.8
26	11 (−5.5; +5.5)	0	0.5	0	92.6	17.6
27	11 (−5.5; +5.5)	0	0	0	96.3	20.4
28	11 (−5.5; +5.5)	−1	0	0	99.5	20.4
29	11 (−5.5; +5.5)	−2	0	0	100.0	20.4
30	10 (−5; +5)	2	0	2	100.5	18.8
31	10 (−5; +5)	2	0	1	91.1	14.2
32	10 (−5; +5)	1	0	1	100.5	19.1
33	10 (−5; +5)	1	0	0	85.3	13.4
34	10 (−5; +5)	0	0	0	91.1	13.7
35	10 (−5; +5)	−1	0	0	97.4	17.9
36	10 (−5; +5)	−2	0	0	98.4	19.4
37	8 (−4; +4)	−2	0	0	92.1	12.2
38	8 (−4; +4)	−3	0	0	97.4	15.4

posterior movement along the y-axis (Fig 4a). In simulations 5 and 6, an additional posterior movement was made (simulation 5: $\Delta y=2$, simulation 6: $\Delta y=1$), while in simulation 7, the fingers remained unmoved on the y-axis ($\Delta y=0$; Fig 4). The reduction in maximum perineal tension in simulation 5 was 2.6 %, in simulation 6 it was 11.6 % compared with 27.9 % in simulation 7. The comparisons of results of other simulations,

in which the only difference was the movement of the fingers along the y-axis, showed a similar pattern (e.g., simulations 12 versus 14 or simulations 20 versus 21 versus 22).

Comparing the sizes of the areas of high tension in these models, the areas in simulations 5 and 6 were comparable (12.8 % for simulation 5 and 12.3 % for simulation 6) and significantly smaller in simulation 7 (8.9 %; see Table 1).
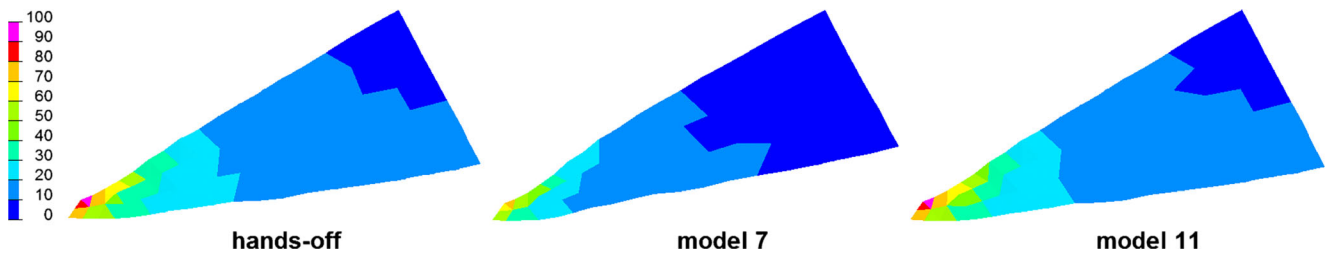
Fig. 3 Mid-sagittal planes of the perineum and stress distribution in the tissue with a color spectrum in multiples of stress units at the moment of fetal head expulsion

Different initial position, identical final position on the y-axis

Simulations 18, 21, and 25 were compared (Fig 4b). Because of the initial position of the fingers and their subsequent movement along the y-axis (simulation 18: y=+3, Δy=2; simulation 21: y=+2, Δy=1; simulation 25: y=+1, Δy=0), the final positions of the fingers were identical (x=±5, y=+1; Fig 4b). The reductions achieved in maximum perineal tension were 3.7 %, 11.6 %, and 13.2 % respectively, and the sizes of the areas of high tension covered 12.4 %, 12.5 %, and 12.8 % of the perineum respectively. The results were consistent when other simulations (e.g., 1, 6, and 14 or 3, 9, and 15) were compared (Table 1).

It can be surmised that the resulting final position of fingers on y=+2 is the most effective. The role of the movement of the fingers along the y-axis is less significant than the final position. However, it seems that for Δy=0 (i.e., when the initial position on the y-axis corresponds to the final position), the reduction in perineal tension is the most profound.

The placement of fingers and their movement
along the x-axis

Identical initial position, different final position on the x-axis

In simulations 6, 9, and 11 the only difference is the extent of the movement of the fingers along the x-axis (Fig 4c). In simulation 6 the fingers were moved bilaterally 1 cm toward the midline (Δx=1), while in simulation 9 the fingers approximated to 0.5 cm on each side (Δx=0.5) and in simulation 11, the fingers were not approximated at all (Δx=0; Fig 4c). The reduction in maximum perineal tension in simulation 6 was 11.6 %, in simulation 9 it was 6.3 %, while no reduction in tension occurred in simulation 11.

Comparing the sizes of the areas of high tension, the area in simulation 6 was 12.3 %, in simulation 9 it was 16.1 %, and in simulation 11 it was 19.3 %. The situation was similar for other simulations, which compared only the difference in the movement of the fingers along the x-axis (e.g., simulations 1

Fig. 4 Scheme of the initial and final locations of the thumb and index finger in various modifications of VMPP on axial planes of the perineum.
a Simulations 5, 6, and 7.
b Simulations 18, 21, and 25.
c Simulations 6, 9, and 11.
d Simulations 7 and 22.
e Simulations 7 and 11
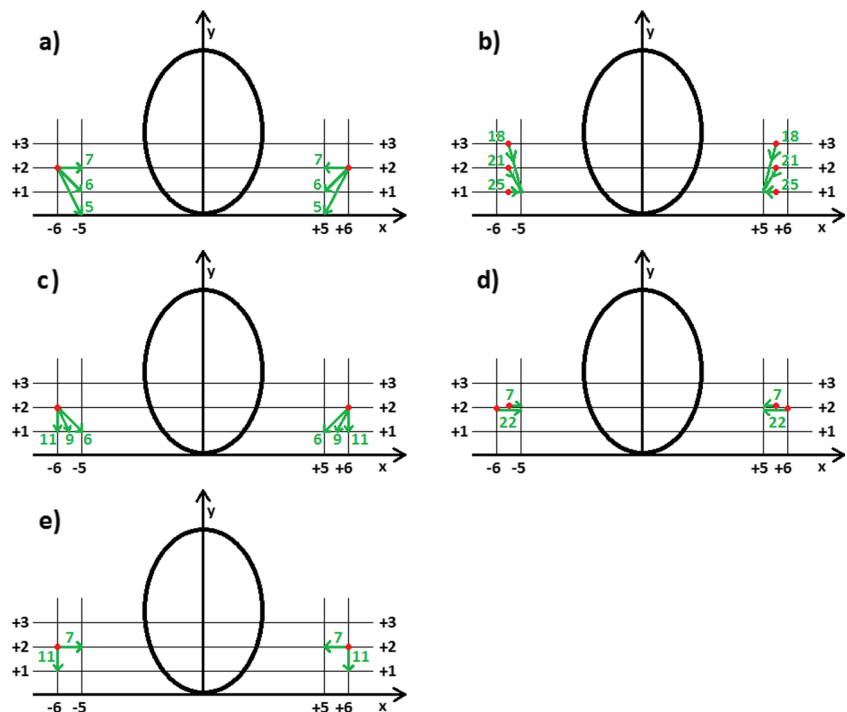
versus 3; 2 versus 4; 21 versus 23). However, in comparisons of simulations 12 versus 13; 14 versus 15; or 16 versus 17 the differences in maximum tension and in the areas of high tension were not significant. The explanation for this finding could be that in these models the final position of the fingers on the y-axis was less than 2 cm anteriorly from the posterior fourchette (i.e., y=+1 for simulations 14 and 15 and y=0 for simulations 12, 13, 16, and 17) Therefore, having been positioned away from the vector of the principal perineal strain, the contraction of the thumb and index finger toward each other could not achieve the full effectiveness.

Different initial position, identical final position on the x-axis

In simulations 7 and 22 the fingers moved from 12 cm apart in simulation 7 (x=±6, Δx=1) and from 11 cm in simulation 22 (x=±5.5, Δx=0.5) to an identical final position at 10 cm apart (x=±5, y=+2; Fig 4d). The reductions in maximum perineal tension achieved were 27.9 % and 22.1 % respectively and the sizes of areas of high tension were 8.9 % and 12.7 % respectively. The measurements showed a similar pattern when other simulations (e.g., 2 and 19) were compared, with a slightly lower degree of similarity for the sets of simulations 6, 21, and 31 and 12, 24, and 32 (Table 1). The explanation for this phenomenon is that fingers in those simulations moved to a final position on the y-axis that was more posterior than 2 cm anteriorly of the fourchette (i.e., y=+1 for simulations 6, 9, and 31 and y=0 for simulations 14, 24, and 33).

Analyzing these simulations, it seems that the extent of the movement of the fingers along the x-axis toward the midline is important for the effectiveness of the procedure, on the condition that this movement occurs anteriorly of the fourchette to a substantial degree (i.e., when y=+2).

The placement of fingers and their movement along both the x- and y-axes

The importance of the mutual co-operation between fingers in both dimensions is documented in the comparisons of simulations 7 and 11 (Fig 4e). The initial placement of both fingers was identical in both simulations (x=±6, y=+2). The fingers were then moved by 1 cm, but in a different direction. In simulation 7, fingers were approximated at 1 cm on each side with no movement along the y-axis (Δx=1, Δy=0) while in simulation 11, fingers were not approximated and moved 1 cm posteriorly (Δx=0, Δy=1) (Fig 4). The difference between the maximum perineal tension achieved was 29 % and the size of the area of high tension was more than twice as large in simulation 11. Comparing these two simulations, a distance of 1 cm in the wrong direction is responsible for nearly 30 % of the difference in the maximum perineal tension using this model.

Discussion

In a biomechanical computerized simulation, VMPP markedly reduces the tension in the perineal body at the point of maximum strain. The exact placement of the fingertips on the perineal skin together with their co-ordinated movement plays an important role in the extent of this reduction.

The previous randomized controlled trials [6, 7] have not found MPP to be effective. However, no information on the exact positioning and subsequent movement of the fingers during MPP was provided by any of these studies. In the light of current findings it seems that these trials were poorly designed and controlled regarding the precision of the execution of MPP [6, 7]. The clear advantage of this modeling over clinical studies is that the simulation could be stopped at any moment during the delivery and the tension measured precisely, which is impossible in a clinical setting. The other advantage is that one variable (i.e., positioning of the fingers) could be changed while others remain unchanged. This allows for comparisons to be easily made between the simulations/deliveries and obstetric interventions, along with the corresponding results.

The main limitation of this study is the material and the set-up of its parameters. There is a lack of data describing the behavior of perineal tissue under load and that is why the authors selected the parameters after repeated tests and evaluations had been performed based on their realistic behavior during the simulation [2].

Generally, there are two types of materials used for soft tissue modeling: viscoelastic and hyperelastic. Viscoelastic material is dependent on the strain rate and the loading history. In order to properly assess the viscoelasticity of the perineal structures, long-time simulations are required. However, the duration of the second stage of vaginal delivery is counted in minutes and simulations using viscoelastic material would require excessive computational effort. Hyperelastic material was adopted for this study as it has been in other similar studies [27, 29, 30].

Two suitable hyperelastic material models can be applied in the solver: the Ogden and Mooney–Rivlin types. In areas of large deformation, these materials differ in the rate in which the change in stress values depends upon the change in strain. Change in stress is smaller for the Mooney–Rivlin material than the Ogden type. As the result of the study should be an evaluation of stress reduction with regard to strain, the reduction when using the Mooney–Rivlin material is expected to be smaller than when using the Ogden material. Therefore, the authors used Mooney–Rivlin material in order to avoid any bias in the results of the study. Moreover, the Mooney–Rivlin material exhibited more stable and realistic behavior during simulation. A precondition of this study was that the experimental results, i.e., the reduction in stress/tension, should never become unrealistically more profound than that in a clinical setting.

In order to achieve realistic behavior of the model, values of an order of GPa were used for coefficients of material parameters [2]. The stress values are linearly dependent on the order of the chosen coefficient values, i.e., 10 times lower values of coefficients result in 10 times lower stress values. The goal of the study was not to compare the absolute values of the stress, but the relative difference in stress/tension between particular versions of the model simulations. Thus, the peak of the stress in the hands-off simulation was selected as the reference value of 100 % and the results of simulations of MPP were related to this value as percentages. This approach compensates for any inaccuracy in the material parameters selected due to the lack of experimental data. Therefore, the selection of values for material parameters, in GPa or in MPa or in kPa, does not affect the results of the study.

This study did not provide a value for exact tissue tension that could represent the threshold for tearing of the perineum. The aim of the study was to find out how to position the fingers on the perineum and how to move them in order to reduce the perineal tension most effectively. Because of the high inter-individual variability in the perineal tissue characteristics amongst women, it is possible that the same maneuver, capable of preserving an intact perineum in one patient, might result in a perineal tear in another. However, using the suggested maneuver, the decrease in maximum perineal tension should be proportionate; thus, the rate and degree of perineal trauma should generally be reduced.

According to the computerized simulation presented in this study, the extent of this reduction depends on the modification used, i.e., on the final finger position and that, for the most part, on the y-axis, and the extent of movement and final position of the fingers mainly depends on the x-axis. To execute MPP effectively, the fingers must be placed sufficiently anteriorly and sufficiently apart following the vector of the principal perineal strain [4]. If the positioning of the fingers moves away from this vector, the effectiveness of MPP is substantially reduced.

Further studies are needed to evaluate whether and to what extent the effectiveness of the optimal placement and co-ordinated movement of the fingertips during VMPP differs in various anatomical settings (fetal head size, edema of the perineum, etc.). Furthermore, a subsequent clinical study based on this simulation ought to be performed to document whether the reduction in maximum perineal tension shown in this study, computational in nature, might play a significant role in a clinical reduction of any of the known adverse anatomical and functional perineal outcomes.

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