CLINICAL ARTICLE

Stereophotogrammetry of the perineum during vaginal delivery

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Abstract

Objective: To analyze deformation of the perineum during normal vaginal delivery in order to identify clinical steps that might be beneficial when executing manual perineal protection. Methods: The present prospective study at Charles University Hospital, Pilsen, Czech Republic, enrolled 10 primiparous women at term undergoing non-instrumental vaginal delivery assisted by the same obstetrician between September 2009 and September 2010. A modified hands-poised technique performed concurrently with stereophotogrammetry was used to analyze and quantify perineal deformation and strain at the final stage of delivery. Results: The highest tissue strain (mean, 177%; 95% confidence interval [CI], 106.3–248.5) was in a transverse direction and occurred at the level of the fourchette (i.e. 1 cm was transversely stretched and deformed to 2.77 cm during the final stage of vaginal delivery). This strain was more than 4 times higher than the maximum anteroposterior strain (mean, 43%; 95% CI, 28.6–57.4). Conclusion: On the basis of these stereophotogrammetry data, a technique of perineal protection executed by fingers of the posterior (right) hand can be proposed. Further experimental and clinical studies are needed to evaluate whether this technique might assist in reducing obstetric perineal trauma.

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1. Introduction

Studies on manual perineal protection (MPP) during the final phase of vaginal delivery have been limited. Although MPP was described in traditional obstetric textbooks [1–3], this intervention is often missing from modern textbooks altogether. Current evidence-based guidance for management decisions during labor and delivery recommends against routinely providing “hands-on” MPP [4]. Both “hands-on” and “hands-off” approaches are accepted for aiding spontaneous vaginal delivery in the UK [5,6]. This acceptance is based on the results of 2 studies [7,8]. A recent British observational study found that nearly half of all midwives surveyed preferred a “hands-off” technique [9]. Similarly, 52% of Australian midwives “almost always” or “frequently” use “hands-off” the perineum [10].

The idea that proper management of the perineum was no longer taught properly was expressed over 120 years ago, when it was also acknowledged that none of the suggested techniques was scientifically credible [11]. At that time, DeWees [11] found that only 2 out of 42 experts supported “total perineal abstaining;” however, perineal support executed by the palm was the approach that was most used. Only 6 out of 30 experts used 2 fingers (thumb and index finger) for MPP, and only 2 of those 6 reported using active coordination between these 2 fingers [11].

To categorize MPP as “hands-on,” “hands-poised,” or “hands-off” techniques is an unsatisfactory simplification of the problem, because previous studies have used these terms to indicate different interventions [4,8,9,12]. This is a sign of our current technical inability to describe this intervention so that it is clearly understandable, and thus reproducible and comparable.

Modern obstetric practices, which are exclusively evidence-based, commonly disregard this intervention [4]. The delivery technique, including the position of the accoucheur’s hands, is not routinely registered in delivery records [13,14], and population-based retrospective studies are difficult to conduct. Only 3 randomized studies have been undertaken in which MPP was categorized into “hands-on,” “hands-poised,” or “hands-off” techniques [8,9,12]. Those studies did not find evidence supporting the concept that MPP is a beneficial procedure.

As a result, the aim of the present study was to describe and quantify deformation and strain of the perineal structures during the final part of delivery and, by derivation from the data collected, to suggest a modification of MPP that might decrease the degree of perineal tension.
2. Materials and methods

The present prospective study conducted at Charles University Hospital, Pilsen, Czech Republic, enrolled primiparous women at term undergoing non-instrumental vaginal delivery assisted by the same obstetrician between September 1, 2009, and September 1, 2010. The study was part of a larger project PEERS 5P’s: the Perineal Evaluation, Education and Repair Study International Group: Perineal Protection Program incorporating the Principles of Physics. The local ethics committee approved the study and all participants signed a detailed informed consent form before they were enrolled.

The time allocated for the study was 2 Fridays (between 12 pm and 12 am) every month over the 12-month study period. The inclusion criteria were primiparity, term singleton pregnancy, vertex presentation, non-instrumental vaginal delivery without episiotomy, neonatal weight of more than 3000 g, competent Czech or English, and a signed informed consent.

Two researchers (an obstetrician and biomechanical engineer) attended each delivery. The obstetrician assisted at all deliveries, and the biomechanical engineer executed all technical work. The obstetrician’s hands did not touch the perineum before crowning of the fetal head. At the time of crowning, the modified “hands-poised” technique was used for MPP [8,9]. In keeping with this technique, the hands were applied to the perineum at the time of expulsion and not before. The anterior hand only slowed down expulsion of the fetal head, and the posterior hand and its fingers were placed alongside the fourchette and vaginal opening precisely at the time of expulsion. That meant that there was no deformation or strain on the perineal tissues.

Stereophotogrammetry was used to analyze deformations in the perineal region. It is a non-invasive method that facilitates reconstruction of an object’s surface in 3-dimensional space by using a pair of images taken from 2 different positions at the same time [15]. The principle of stereophotogrammetry resembles human eye vision. The investigated object is photographed by 2 digital cameras. To perform a reconstruction of the object’s surface, it is necessary to know the exact position and orientation of the 2 cameras with respect to a chosen reference system, and also the parameters of the lenses. These parameters are obtained through calibration of the scene by photographing a calibration grid first instead of the object of interest. The image coordinates of chosen points on the calibration grid, together with these points on the investigated object, are used to calculate real coordinates in the reference system.

The search for pairs of corresponding image points was performed by using the digital image correlation technique [16]. Assessment of the depth of the image was made via a mathematical model based on direct linear transformation [17]. If 2 states are processed in this way (i.e., before and after an object’s deformation), it is possible to assess the components of mechanical strain (deformation) by comparing the corresponding displacement vectors of the individual points on the surface.

Given the character and speed of vaginal delivery, a system with large image resolution (10 megapixels) was used. A pair of cameras (Canon EOS D400 and D450 with Sigma 105-mm lenses) were placed approximately 1.5 m (mean, 1.49; range, 1.05–1.89) apart, and 2.4 m (mean, 2.41 and 2.46; range, 1.68–2.82 and 1.92–2.87) from the participant. Standard hospital lighting was used without any flash that could disturb the participant. Snapshots were taken manually using a synchronized remote control at a rate of approximately 1 per second during each contraction. The sequence of snapshots was then analyzed and post-processed via a stereophotogrammetry code that was written in-house.

The perineum was marked with small dark green dots (with a 1% aqueous solution of collodion stained with brilliant green). The number of dots varied between 54 and 116. The points visible in every frame were selected for the creation of a mesh composed of triangles (Fig. 1). The displacements were calculated for each point as it moved in time. The strains (deformations) were then calculated via each triangle as it deformed through time under the assumption that the strain components (dilational, shear) were constant across the area of each triangle. Thus, a deformation field was determined on the mesh representing the surface of the perineal region.

The soft tissues of the perineal region are highly heterogeneous materials, and their mechanical response is nonlinear and anisotropic. Because the complex material properties of the perineal tissues are not known with any precision, only strain values that are commonly used in mechanics, such as the maximum ($\varepsilon_1$) and minimum ($\varepsilon_2$) principal strains, maximum shear strain ($\gamma_{\text{max}}$), and equivalent strain ($\varepsilon_{\text{eq}}$), were investigated in the study. These strains are invariants; that is, they are independent of the chosen reference coordinate system (position of cameras) because at every point on the surface, the deformation can be uniquely described by a combination of 3 numbers: either by 2 normal strain components $\varepsilon_x$ and $\varepsilon_y$ (elongation, shrinking), and 1 shear strain $\gamma_{xy}$ (change in angle between perpendicular lines) with respect to a chosen Cartesian coordinate system $x$-$y$; or by 2 principal strains $\varepsilon_1$ and $\varepsilon_2$ along 2 principal directions 1 and 2, and 1 angle defining the rotation between the $x$-$y$ and 1–2 axes. There is always 1 possible (or an infinite number) rotation of system $x$-$y$ for which the shear strain is 0 [15]; in this case, the axes $x$-$y$ coincide with the principal directions 1 and 2 ($\varepsilon_1 \geq \varepsilon_2$). The latter quantities of interest are defined as $\gamma_{\text{max}} = \varepsilon_1 - \varepsilon_2$ and $\varepsilon_{\text{eq}} = \sqrt{(\varepsilon_1^2 + \varepsilon_2^2 - \varepsilon_1\varepsilon_2)}$.

In the present study, the strain was investigated for each participant at the last possible moment of delivery (immediately before fetal head expulsion), and in contrast to the original configuration—that is, the configuration when the participant was positioned on the bed (before active pushing) and the obstetrician applied the dotted pattern.

Statistical analysis was performed with STATISTICA version 9.0 (StatSoft, Tulsa, OK, USA). Basic statistical values (such as mean, median, standard deviation, variance, minimum, maximum, quantile, and frequency) were computed for the study. The relations among the variables investigated were described via Spearman correlation coefficients. A $P$ value of less than 0.05 was considered to be statistically significant.

3. Results

During the study period, 15 primigravid women fulfilled the inclusion criteria, consented, and were enrolled in the study before delivery. Among these women, 2 underwent cesarean delivery, and episiotomies were performed on another 3 because of fetal distress. These 5 women were, therefore, excluded from the study.

Among the remaining 10 women included in the study, 4 had an intact perineum, whereas 2 had first-degree and 4 had second-degree tears after delivery. The neonatal umbilical artery pH was lower than 7.20 in 2 cases. The obstetric data of the study group were performed on another 3 because of fetal distress. These 5 women were, therefore, excluded from the study.

The remaining 10 women included in the study, 4 had an intact perineum, whereas 2 had first-degree and 4 had second-degree tears after delivery. The neonatal umbilical artery pH was lower than 7.20 in 2 cases. The obstetric data of the study group were summarized in Table 2. The maximum and minimum values correspond to the whole mesh. Positive values of $\varepsilon_1$ and $\varepsilon_2$ denote tension, whereas negative values denote compression.

An example of the contours of the maximum principal strain $\varepsilon_1$ on the deformed mesh is shown in Fig. 2, together with the real position of the original mesh in the background. The axes $x$, $y$, and $z$ correspond to the reference coordinate system defined by the position of cameras. An example of directions corresponding to the maximum (red) and minimum (green) principal strains is shown in Fig. 3. The lengths of the lines are also proportional to the values of the strains.

The location undergoing the largest strain was always in the area of the posterior fourchette (mean, 177%; 95% confidence interval [CI], 106.3–248.5). The maximum principal strain was predominantly
oriented in the transverse direction (Fig. 3, longest red line). The highest maximum anteroposterior strain was in the midline (mean, 43%; 95% CI, 28.6–57.4).

Of the obstetric variables measured, head circumference and neonatal weight were found to be significant in relation to the ratio of the perineal transverse strain to the anteroposterior maximum strain (P<0.01) (Table 3).

4. Discussion

The present results show that the highest tissue strain occurs at the posterior fourchette. The highest tissue strain was in a transverse direction at the level of the fourchette (i.e. 1 cm was transversely stretched and deformed to 2.77 cm during the final stage of vaginal delivery), and was more than 4 times higher than the maximum anteroposterior strain. If we accept the validity of the maximum strain criterion used for anisotropic materials [18], this area would be the critical location prone to tearing.

The 3 previous randomized studies comparing different techniques of MPP did not obtain clear data [8,9,12]. In the study of Albers et al. [12], the use of warm compresses, perineal massage with lubricants, and “no touch” of the perineum until crowning of the fetal head were compared. No further explanation was provided; thus, it is not clear what was performed during the crowning, or whether, at the final phase, a modification of the “hands-on” technique was provided.

The other 2 studies described the “hands-on” technique either as pressure placed on the fetal head to maintain the flexion and “guard the perineum” [8] or as “placing the right hand against the perineum for support” [9]. The terms “guard” and “support” the perineum were not further defined. Furthermore, no rectal exam was performed prior to suturing in the previous studies [8,9,12]; as a result, the information on the incidence of anal sphincter injury provided by these studies may be questionable.

Conversely, MPP has been found to reduce severe perineal tears in other studies [19–23]. In 3 of those studies only, MPP was described to some extent together with a picture with the position of the fingers of the posterior hand [21–23]. There was no description of the coordination between fingers, however, making it difficult to understand MPP and subsequently to reproduce it.

Given the principles of mechanics, there are 4 ways to reduce perineal strain and tension: decrease frictional forces; increase the elasticity of the perineum; decrease the size of the passing object—that is, minimize the largest head circumference (the suboccipitobregmatic circumference should pass through the perineal structures); or redistribute the perineal tension to reduce the localized perineal tension at

Table 1
Obstetric data of the study group.

<table>
<thead>
<tr>
<th>Procedure-independent characteristics</th>
<th>Obstetric data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maternal age, y</td>
<td>29.50 (23–34)</td>
</tr>
<tr>
<td>Body mass index</td>
<td>28.70 (23.0–37.9)</td>
</tr>
<tr>
<td>Duration of the second stage of labor, min</td>
<td>24 (15–106)</td>
</tr>
<tr>
<td>Head circumference, cm</td>
<td>34 (32–37)</td>
</tr>
<tr>
<td>Neonatal weight, g</td>
<td>3530 (3220–4730)</td>
</tr>
<tr>
<td>Apgar score at 1 min</td>
<td>9 (5–10)</td>
</tr>
<tr>
<td>Apgar score at 5 min</td>
<td>10 (8–10)</td>
</tr>
</tbody>
</table>

* Calculated as weight in kilograms divided by the square of height in meters.

<table>
<thead>
<tr>
<th>Procedure-related characteristics</th>
<th>Median (range)</th>
<th>Mean±SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>ε1, x</td>
<td>Min 0 (−11.53 to 0)</td>
<td>−2.0±3.87</td>
</tr>
<tr>
<td></td>
<td>Max 136.32 (76.83–381.20)</td>
<td>177.40±99.42</td>
</tr>
<tr>
<td>ε2, x</td>
<td>Min −38.35 (−79.61 to −16.62)</td>
<td>41.65±18.98</td>
</tr>
<tr>
<td></td>
<td>Max 40.35 (8.21–70.39)</td>
<td>42.97±20.13</td>
</tr>
<tr>
<td>γmax</td>
<td>Max 1.18 (0.73–4.11)</td>
<td>1.74±1.04</td>
</tr>
<tr>
<td>εeq, x</td>
<td>Max 125.90 (77.31–396.83)</td>
<td>176.60±100.85</td>
</tr>
<tr>
<td>ε1 max/ε2 max</td>
<td>Max 3.75 (2.24–5.35)</td>
<td>4.60±2.27</td>
</tr>
</tbody>
</table>

Abbreviations: ε1, maximum principal strain; ε2, principal strain in the area of each triangle perpendicular to the maximum principal strain; γmax, maximum shear strain; εeq, equivalent strain.

Fig. 1. The experimental mesh composed of triangles defined by dark green dots on the perineum. Shown is an example of the dot pattern applied and triangular areas (mesh) generated on 1 participant as seen from the left (L) and right (R) cameras at the original (0) and deformed (1) configurations. Values on the axes are given in pixels.
its maximum point by spreading the peak over a larger area (smearing) with regard to transverse tension and anteroposterior tension.

It is known that most severe perineal tears happen during the second stage of labor at the final phase of vaginal delivery. As a result, it is important to describe all dynamic changes on the perineum to understand the biomechanics of perineal trauma. On the basis of the surface geometry, the anus undergoes considerable changes during vaginal delivery and the anal sphincter dilates to an average of 25 mm [24]. Because the head dilates the vaginal orifice and the suboccipitobregmatic circumference has to be delivered, it is no use executing MPP before the fetal head crowns (i.e. there is no recession of the head between contractions because the biparietal diameter has passed through the bony pelvis).

The present study is a first step toward achieving a scientific calculation to determine the technique of MPP that should be used. If MPP is to be beneficial and reproducible, it must be described in detail, including the role of the anterior (left) hand; positioning of the palm, thumb, index, and middle-finger of the posterior (right) hand; and at what time and in which direction the gentle manual filigrane should be executed to reduce the degree of perineal trauma.

On the basis of the present results, we suggest the approach of relieving the transverse strain (and tension) by placing the posterior (right) hand so that the ulnar side of the thumb and radial side of the index finger are placed alongside the fourchette and vaginal opening—that is, the Vienna method [16]. To reduce the tension in the midline, the finger tips should be firmly pressed against the perineum and a region of parietal eminences of the fetal head, and should be pulled toward each other—mainly at the time of pushing—by contracting the superficial and deep flexor digitorum, the thenar muscles (especially the flexor and adductor of the thumb), the first (and occasionally also the second) lumbrical, and the first interosseus muscles.

The palm (or flexed remaining fingers) might be placed on the median part of the perineum to provide gentle support to the crowning head at the point of the highest anteroposterior strain. Whether the middle finger should be placed close to the index finger or used in another way [21–23] is a matter for further research. Whether the contraction of the accoucheur’s palmar muscles in the proposed way is clinically feasible, and whether this contraction can release the strain throughout the thickness of the perineal body, has yet to be tested.

Previous unsatisfactory results from countries where the “hands-off” technique has recently been widely adopted enforce a scientific re-evaluation of the traditional method known and practiced for centuries. The present study has described quantified stereophotogrammetry data regarding the perineal strain and its direction during vaginal delivery. Further experimental and clinical studies must evaluate whether these data and their analysis might assist in the future reduction of obstetric perineal trauma.

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Conflict of interest

The authors have no conflicts of interest.

References


