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The recovery of pelvic organ support during the first year postpartum

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Objective Compare changes in pelvic organ prolapse (POP) from 36–38 weeks of gestation to 1 year postpartum after unlaboured cesarean delivery(UCD)and trial of labour (TOL).

Design Prospective observational cohort study.

Setting Wenzhou Third People's Hospital, Wenzhou, Zhejiang, China.

Population Nulliparous women undergoing UCD or TOL.

Methods Pelvic organ prolapse was assessed at 36–38 weeks of gestation, then at 6 weeks, 6 months and 1 year postpartum, using the Pelvic Organ Prolapse Quantification (POPQ) system.

Main outcome measures Postpartum POP status in UCD and TOL determined by POPQ measurements over time.

Results Points Aa (Ba) determined the final stage assignment in most cases. Stage II POP was present in 35% and 37% of women in UCD and TOL at 36–38 weeks of gestation. After delivery, the likelihood of stage II POP declined during the first year postpartum in the whole cohort. The TOL group was much less likely to recover from stage II POP compared with the UCD group (odds ratio 0.04, 95% confidence interval 0.01–0.18) after adjustment for POP status at 36–38 weeks of gestation, age, first-trimester body mass index, newborn birthweight, educational level, gravidity and smoking status. With the exception of age, education and gravidity, these covariates were also independent predictors of postpartum POP.

Conclusion Factors unique to labour and delivery lead to sustained pelvic floor relaxation postpartum. Pelvic organ prolapse at 36–38 weeks of gestation, and higher first-trimester body mass index also appear to predict long-term POP. Further investigation into mechanisms leading to persistent or progressive POP after TOL are warranted. In addition, caution is needed in generalising the findings due to the single-centre design.

Keywords Caesarean delivery, pelvic organ prolapse, pelvic organ prolapse quantification, pelvic organ support, postpartum, trial of labour.

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Introduction

Pelvic organ prolapse (POP) is a common problem. Approximately 50% of women undergoing routine gynaecological examinations demonstrate some evidence of POP.[1,2] It is estimated that women have an 11.1% risk of undergoing at least one operation for either POP or urinary incontinence by the age of 80.[3,4] Pelvic organ prolapse has significant negative effects on women's quality of life and the economic consequences are anticipated to escalate with the projected increase in POP to more than 4.9 million women in the USA alone, by 2050.[5]

Parity is a well-established risk factor for the development of POP.[6–11] The current body of evidence suggests that alterations in pelvic organ support during pregnancy and the puerperium may increase a woman's risk for POP up to eight-fold after one vaginal delivery and 20-fold following three vaginal deliveries, compared with women having the same number of caesarean deliveries.[10,12,13] During pregnancy, hormonal changes that prepare the pelvic floor for delivery and the increased pressure from the gravid uterus may be involved in pelvic floor relaxation. Thereafter, the passage of the baby through the birth canal is thought to result in a mechanical distortion that damages the pelvic floor connective tissue and muscular supportive structures, as well as the nerves and vessels that supply these structures.[14–17] Ultimately, these changes may lead to persistent or permanent modifications in the proper func-

tion of pelvic floor muscles. To date, our understanding of short-term and long-term structural changes in the pelvic floor that are acquired as a consequence of pregnancy and the puerperium have not been well characterised.

The introduction of the pelvic organ prolapse quantification (POPQ) system has allowed researchers to detect minimal descents in the different compartments of the pelvic floor. The purpose of this study was to evaluate objective changes in pelvic organ support in women undergoing unlaboured caesarean section (UCD) or trial of labour (TOL) from pregnancy to 1-year postpartum in a population of nulliparous women.

Methods

This was an Institutional Review Board approved, prospective, observational study conducted in an obstetrics clinic in Wenzhou Third People's Hospital, in Wenzhou, Zhejiang, China. A total of 110 nulliparous women who were at 36–38 weeks of gestation and were planning to undergo an elective caesarean delivery or a TOL between 1 April 2009 and 31 May 2009 were recruited for participation during their routine prenatal care visit. All women with a normal, uncomplicated singleton gestation who presented to the clinical practice of the study investigator YC were invited to participate. Women were excluded if they had preterm labour, vaginal bleeding, multiple gestations, prior pelvic surgery, a known collagen vascular disorder, a pregnancy complication that precluded vaginal examination, such as placenta praevia, or if they declined participation. As UCD is much less common than TOL, recruitment was continued in both groups until the requisite 25 women were enrolled in UCD to avoid any bias in the study populations. Written informed consent was obtained from each woman who participated in the study before enrolment.

Pelvic organ support was assessed in all enrolled women, at 36–38 weeks of gestation, before the onset of labour, as well as at 6 weeks, 6 months and 1 year postpartum using the POPQ system. The examination was performed with the women in the lithotomy position. Each distance was measured using a wooden spatula marked at 1 cm intervals, and recorded in 0.5 cm increments. We obtained the individual POPQ point measurements corresponding to the anterior (Aa, Ba), apical (C, D) and posterior compartments (Ap, Bp) as well as the genital hiatus and perineal body during maximal Valsalva effort. While maximal descent may not be elicited in the lithotomy position,[18] we wanted to ensure that consistency was maintained for all evaluations over time. Therefore, before initiating the study, the decision was made to perform POPQ in the lithotomy position to avoid any unnecessary interventions that may pose actual or perceived increased risk to the women in the advanced stages of pregnancy. If the woman was unwilling, embarrassed or judged to not perform adequate Valsalva, the measurements were taken with the woman coughing forcefully after being coached by the examiner. Total vaginal length was measured at rest. POP was defined as at least stage II descent and was determined on the basis of the most prolapsed compartment using standard criteria.[19] To ensure consistency of testing, all women were examined and evaluated by the same experienced gynaecologist (YC), who was not involved in the labour, delivery or immediate postpartum management of any of the participants.

Demographic information including age, educational level, gravidity, smoking and breastfeeding status was collected 6 weeks postpartum. The height and weight were recorded at each evaluation as well as during the first trimester. Body mass index (BMI) was calculated as weight in kilograms/height in metres squared (kg/m^2). Postpartum information about the mode of delivery and the newborn birth weight (NBW) was obtained from the clinical charts.

Participants were stratified into two groups. The UCD group included women who were scheduled for and underwent a caesarean delivery before the onset of labour. The TOL group comprised women who underwent a trial of labour. Labour was defined as regular, painful uterine contractions resulting in progressive cervical effacement and dilatation. Previous reports have documented that the prevalence of stage II POPQ at 6 weeks postpartum is approximately 45%, with a notable decrease to approximately 8% in women who undergo caesarean delivery.[20,21] The primary endpoint of this study was POP stage at 6 weeks postpartum in UCD compared with TOL. Based on these prevalence data from other studies, it was determined that 25 women would be needed per group to detect a 37% difference in POPQ stage distribution between the two groups with 90% power to reject the null hypothesis, assuming a type I error of 0.05, or with 75% power if using a type I error of 0.01.

Descriptive data are reported as means ± standard deviation or frequency (percentages). Baseline characteristics were compared between groups using chi-square test or Fisher's exact test for categorical variables and Student's *t* test for continuous variables as appropriate. A mixed model repeated measurements analysis was performed to compare the postpartum trend for POPQ point measurements with covariate adjustment for measurements at 36–38 weeks of gestation. To account for the correlation between repeated measurements, a compound symmetry covariance structure was used based on the similar observed standard deviations over time. Fixed effects included group, time, age, first-trimester and 36–38-week BMI, education, NBW, gravidity, smoking status and breastfeeding as well as quadratic time and group by time interaction. *Post hoc* group comparison at three time-points

was performed when group-by-time interaction was significant. A conservative $P \leq 0.01$ was used as the significance cut-off value for adjustment of multiple comparisons. The method of generalised estimating equations was used to model the binary POP outcome that was correlated within repeated observations. The covariate adjustment was the same as that for the mixed model method. Significance was set at 5% ($P \leq 0.05$), unless otherwise specified. Statistical analysis was performed with SAS 9.2 (SAS Institute, Cary, NC, USA).

Results

Two women achieved active labour before undergoing a caesarean delivery and were ineligible for the study. The remaining 108 women completed the study without loss to follow up. Data from 108 women were analysed, including 29 women who underwent UCD and 79 women who underwent TOL. In the TOL group, 65 women delivered vaginally (63 spontaneous and two forceps) and the remaining 14 women delivered by caesarean section. Table 1 shows the characteristics for the women in each group. The UCD group was on average, 1 year older than the TOL group ($P = 0.05$) and had a significantly greater BMI in the first trimester and at 36–38 weeks of gestation. At 36–38 weeks of gestation, the UCD and TOL groups had comparable POPQ point measurements with the exception of less posterior vaginal wall descent (points Ap and Bp) in the TOL group (UCD versus TOL: -2.6 ± 0.3 versus -2.7 ± 0.4, $P = 0.02$).

Table 2 summarises the estimations of effects in multivariate repeated measurements analysis for each of the POPQ point measurements. Baseline effect at 36–38 weeks of gestation was significant for all of the measurements. More pelvic floor descent at 36–38 weeks of gestation resulted in greater overall postpartum pelvic floor relaxation.

For points Aa and Ba, the values reflected less descent at each subsequent time-point. The rate of reduction of pelvic floor relaxation increased more dramatically at 6 weeks postpartum but gradually slowed down with time, as indicated by the quadratic effect. There was also a significant group effect; however, the group-by-time interaction did not reach significance. Specifically, the UCD group had less descent than TOL postpartum with a consistent difference noted at all time-points (effect and SE: 0.59 ± 0.09, $P < 0.0001$). Higher baseline BMI correlated with more anterior wall descent whereas higher NBW correlated with less descent.

For points Ap and Bp, the group-by-time interaction revealed that the magnitude of the difference between UCD and TOL increased significantly over time (effect and SE: 0.09 ± 0.05 at 6 weeks, 0.12 ± 0.05 at 6 months, 0.15 ± 0.05 at 1 year postpartum, *P*-values 0.05, 0.01 and 0.003, respectively). Adjusting for multiple comparisons, the UCD group had significantly less posterior wall descent than the TOL group at 6 months and 1 year postpartum.

For point C, the time effect, group-by-time interaction and the group-by-quadratic time effects were significant ($P < 0.0001$, 0.001 and 0.003, respectively). The UCD group had less descent than the TOL group at all three time-points postpartum and the magnitude of the difference increased over time (differences of 0.27 ± 0.10 at 6 weeks, 0.61 ± 0.10 at 6 months and 0.58 ± 0.10 at 1 year postpartum ($P = 0.01$, <0.0001 and <0.0001, respectively). The rate of ascent of point C increased more dramatically at 6 weeks postpartum and gradually slowed down with increased time.

For total vaginal length, the time effect was very small but it was significant. The UCD group had consistently

Table 1. Baseline characteristics: data are presented as *n* (%) for categorical variables and mean (SD) for continuous variables

Variables	UCD (*n* = 29)	TOL (*n* = 79)	*P*-values
Age	27.4 (2.9)	26.3 (2.4)	0.05
BMI at first trimester	20.7 (2)	19.4 (1.7)	0.0005
Gravidity			0.18
1	16 (59.3)	53 (67.1)	
2	4 (14.8)	17 (21.5)	
>2	7 (25.9)	9 (11.4)	
Smoking status			0.71
No	27 (93.1)	75 (94.9)	
Yes	2 (6.9)	4 (5.1)	
Education			0.98
Primary, Grade 6	4 (13.8)	10 (12.7)	
Secondary, Grades 9–12	13 (44.8)	35 (44.3)	
College	12 (41.4)	34 (43.0)	
Breastfeeding status			0.23
No	10 (35.7)	19 (24.1)	
Yes	18 (64.3)	60 (76.0)	
NBW (g)	3474.1 (408.1)	3335.4 (417.3)	0.13
POP at 36–38 weeks of gestation			0.83
Yes	10 (34.5)	29 (36.7)	
No	19 (65.5)	50 (63.3)	
POPQ components at 36–38 weeks of gestation*			
Aa/Ba	1.7 (0.7)	1.7 (0.6)	0.69
Ap/Bp	2.6 (0.3)	2.7 (0.4)	0.02
Perineal body	2.5 (0.7)	2.4 (0.5)	0.87
Genital hiatus	3.1 (0.6)	2.9 (0.6)	0.09
C	3.3 (1.1)	3.3 (0.8)	0.98
D	6.8 (0.6)	6.8 (0.8)	0.81
Total vaginal length	8.0 (0.7)	7.7 (0.8)	0.08

Chi-square test or Fisher's exact test were used for categorical variables and Student's *t* test was used for continuous variables to compare between group differences.
*Absolute value for POPQ components Aa/Ba, Ap/Bp, C, D were presented but all measured values had a negative sign.

Table 2. Repeated measurement analysis comparing the postpartum change of POPQ component measurement: data are presented as coefficient (SE) for upper panel, and *P*-value for lower panel

Effects/outcomes	Aa or Ba	Ap or Bp	PB	GH	C	TVL
Baseline at 36–38 weeks of gestation	0.60 (0.06) <0.0001	0.33 (0.06) <0.0001	0.69 (0.06) <0.0001	0.55 (0.05) <0.0001	0.73 (0.04) <0.0001	0.72 (0.07) <0.0001
Time	0.02 (0.004) <0.0001	3E–4 (3E–4) 0.43	2E–4 (1E–4) 0.10	2E–4 (2E–4) 0.24	−0.02 (0.004) <0.0001	−0.003 (0.001) 0.04
Time*Time	−2E–4 (7E–5) 0.005	–	–	–	3E–4 (6E–5) <0.0001	5E–5 (2E–5) 0.04
UCD (ref = TOL)	0.57 (0.09) <0.0001	0.09 (0.05) 0.09	0.06 (0.08) 0.41	−0.08 (0.08) 0.30	0.10 (0.12) 0.40	−0.31 (0.12) 0.01
UCD*Time	–	1E–3 (7E–4) 0.05	–	–	0.03 (0.01) <0.001	–
UCD*Time*Time	–	–	–	–	−4E–4 (1E–4) 0.003	–
Age, years	−0.02 (0.02) 0.15	−0.003(0.01) 0.74	−0.03(0.01) 0.06	1E–3(0.01) 0.94	−0.02 (0.02) 0.13	3E–4(0.02) 0.99
BMI at first trimester	−0.08 (0.02) 0.001	0.02 (0.01) 0.10	1E–3(0.01) 0.99	0.04 (0.02) 0.07	5E–3(0.02) 0.83	−0.01 (0.03) 0.67
Education	0.49	0.14	0.01	0.79	0.01	0.64
Primary, grades 1–6	−0.01 (0.12) 0.88	−0.11 (0.06) 0.07	0.18 (0.10) 0.07	0.07 (0.10) 0.51	−0.23 (0.12) 0.05	−0.14 (0.15) 0.38
Secondary, grade 7–12	−0.08 (0.09) 0.35	−0.06 (0.04) 0.19	0.20 (0.07) 0.006	2E–3(0.07) 0.98	0.13 (0.08) 0.12	−0.06 (0.11) 0.57
College	0	0	0	0	0	0
NBW (kg)	0.28 (0.10) 0.007	0.08 (0.05) 0.09	−0.07 (0.08) 0.38	0.06 (0.08) 0.47	0.16 (0.09) 0.08	0.15(0.12) 0.21
Smoking	0.07 (0.17) 0.70	−0.05 (0.08) 0.52	0.12 (0.14) 0.41	−0.16 (0.15) 0.27	−0.16 (0.16) 0.32	0.05 (0.22) 0.82
Gravidity	−0.08 (0.06) 0.18	−0.05 (0.03) 0.08	−0.02 (0.05) 0.73	−0.02 (0.05) 0.66	−0.03(0.05) 0.55	−0.07 (0.07) 0.31

shorter total vaginal length compared with the TOL group (difference: 0.31 ± 0.11, $P = 0.01$). Neither group nor time effects were significant for points perineal body or genital hiatus. Figure 1 presents the postpartum changes for POPQ measurements from both modelling prediction (closed symbols and lines) and observed data (open symbols).

The effects of time, quadratic time and group were all significant in the generalised estimating equations analysis (Table 3). The interaction of group by time did not reach significance ($P = 0.32$) and was excluded in the final model. The odds ratio (OR) was consistent over time during the first year postpartum after adjustment for POP status at 36–38 weeks of gestation, baseline BMI, age, education, NBW and smoking status (adjusted OR 0.04, 95% confidence interval [95% CI] 0.01–0.18, $P < 0.0001$), indicating a 96% lower likelihood of POP in the UCD group compared with the TOL group. POP at 36–38 weeks of gestation was a significant predictor of POP postpartum (adjusted OR 8.2, 95% CI 3.07–21.9, $P < 0.0001$). Moreover, a greater baseline BMI was associated with a higher likelihood of POP whereas a greater NBW and smoking appeared to be protective. The change in the likelihood of POP for UCD and TOL over the three postpartum timepoints is shown in Figure 2. The odds of POP decreased over time in both groups but the decreased odds of POP for the UCD group compared with the TOL group remained unchanged.

To determine if caesarean section after TOL had a similar benefit as UCD, generalised estimating equations analysis was performed comparing the UCD group with the subset of TOL who underwent a caesarean section (Table 4). The group effect remained significant, showing that UCD was significantly more protective against POP than caesarean section after TOL (UCD versus TOL, OR 0.01, 95% CI 0.00–0.13, $P = 0.0002$, Figure 3).

Discussion

Main findings

This prospective, observational study allowed for the discovery of short-term and long-term changes following the pelvic floor accommodation and remodelling that occur in

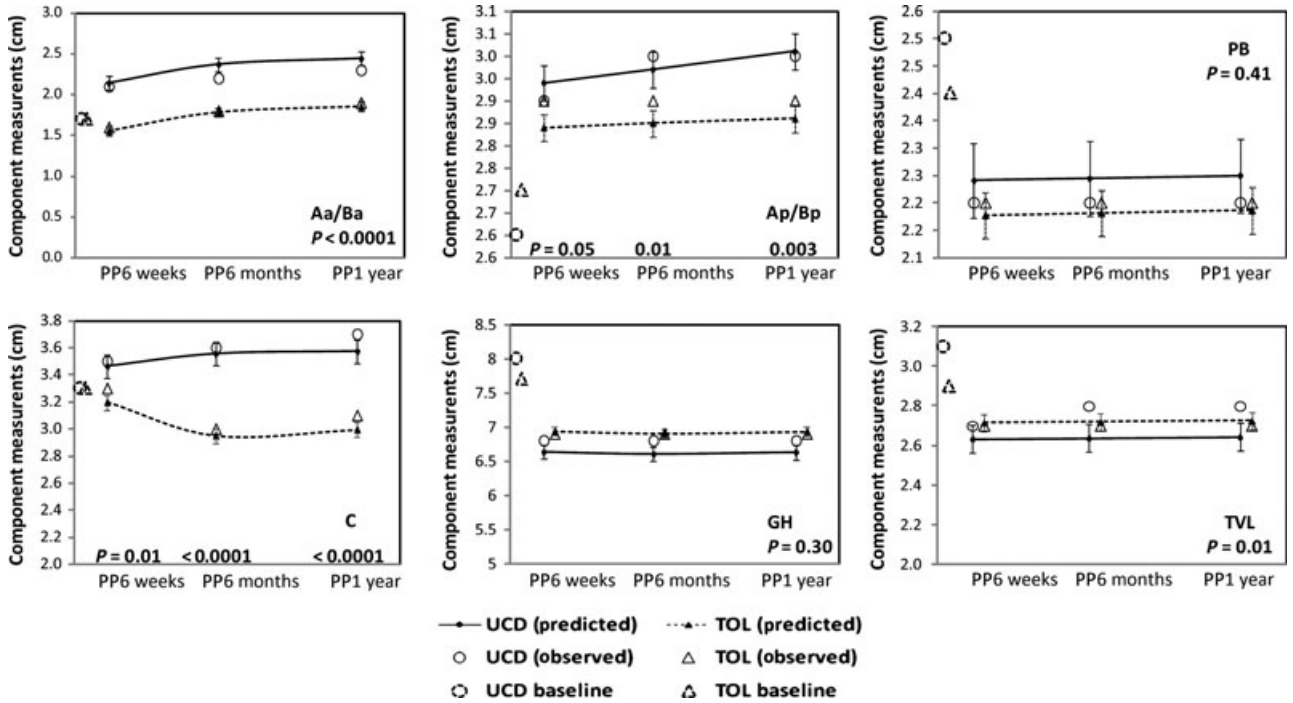

Figure 1. Postpartum changes for POPQ measurements from both modelling prediction (close symbols and lines) and observed data (open symbols). In the graphs of Aa/Ba, Ap/Bp and C, the *y*-axis shows the absolute values relative to the hymen (cm). The true values of these points are negative numbers. In the graphs of perineal body (PB), genital hiatus (GH) and total vaginal length (TVL), the *y*-axis shows the true measurement value (cm). The *x*-axis shows the three time-points postpartum: 6 weeks (PP6w), 6 months (PP6m) and 1 year (PP1y) postpartum.

Table 3. Generalised estimating equations approach predicting the risk to POP in UCD and TOL

Effect	OR*	95% CI		*P* value
POP at 36–38 weeks of gestation	8.19	3.07	21.9	<0.0001
Time	0.92	0.88	0.96	0.0001
Time*Time	1.00	1.00	1.00	0.003
UCD	0.04	0.01	0.18	<0.0001
TOL	1.00	–	–	
Baseline BMI	1.31	1.01	1.70	0.04
Age	1.10	0.91	1.33	0.34
Education				0.99
Primary	0.99	0.22	4.43	0.99
Secondary	0.94	0.35	2.50	0.90
College	1.00	–	–	–
NBW	0.31	0.11	0.93	0.04
Smoking	0.36	0.16	0.84	0.02
Gravidity	1.21	0.67	2.18	0.52

*Adjusted for POP status at 36–38 weeks of gestation, baseline BMI, age, birthweight, education, smoking status and gravidity.

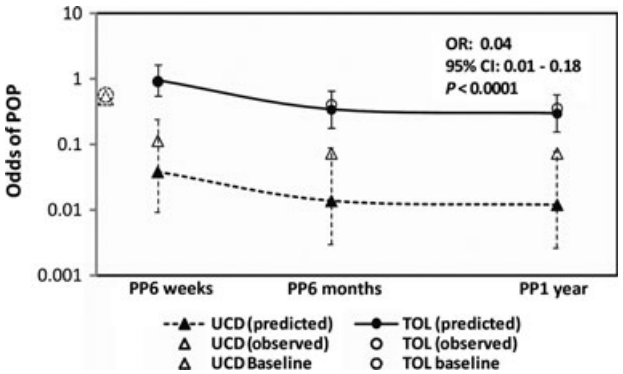

Figure 2. Postpartum changes for risk of POP in UCD and TOL from generalised estimating equations for predicted data (close symbols and lines) and observed data (open symbols). The *y*-axis shows odds of POP and *x*-axis shows the three time-points postpartum: 6 weeks (PP6w), 6 months (PP6m) and 1 year (PP1y) postpartum.

response to labour and delivery in nulliparous women. Our data suggest that significant stage II POP occurs during the third trimester of pregnancy and is predictive of postpartum POP. Although the likelihood of POP declined significantly during the first year postpartum in the whole cohort, the TOL group was much less likely to recover from stage II POP compared with the UCD group at all time-points. Higher first-trimester BMI, lower NBW and non-smoking were also predictive of POP at 1 year postpartum.

Our data also identified, Point Aa/Ba as the pivotal measurement that decided the final stage assignment in most

Table 4. Generalised estimating equations approach predicting the risk to POP in UCD and subgroup of TOL who went to caesarean section

Effect	OR*	95% CI		*P* value
POP at 36–38 weeks of gestation	2.48	2.00	69.86	0.006
Time	1.02	0.96	1.02	0.71
UCD	0.01	0.00	0.13	0.0002
TOL	1.00	–	–	–
Baseline BMI	2.18	1.37	3.48	0.001
Age	1.07	0.61	1.87	0.82
NBW	0.02	0.00	0.35	0.007
Gravidity	1.26	0.30	5.29	0.75

*Adjusted for POP status at 36–38 weeks of gestation, baseline BMI, age, birthweight and gravidity.

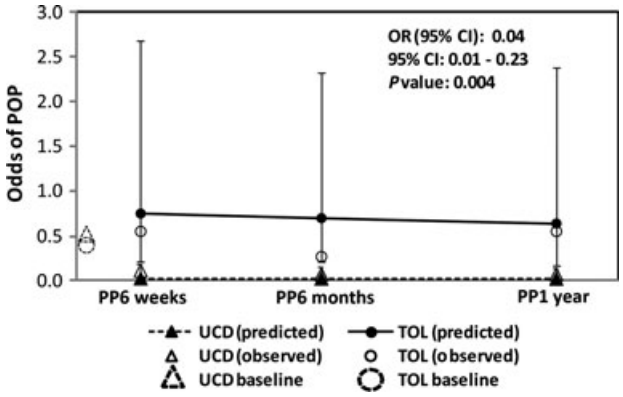

Figure 3. Postpartum changes for risk to POP in UCD and subgroup of TOL who went to caesarean section from generalised estimating equations for predicted data (close symbols and lines) and observed data (open symbols). The *y*-axis shows odds of POP and *x*-axis shows the three time-points postpartum: 6 weeks (PP6w), 6 months (PP6m) and 1 year (PP1y) postpartum.

cases. The UCD group also had less posterior and apical wall descent than TOL. Moreover, our data suggest that caesarean delivery after TOL does not confer the same protection against POP as UCD. Collectively, these findings confirm that long-lasting changes occur in pelvic floor architecture during pregnancy that lead to a significantly increased risk of sustained pelvic floor relaxation after labour and delivery.

Strengths and limitations

Our study remains unique in that serial evaluations using objective measures were obtained in over 100 women from pregnancy to 1 year postpartum. Whereas other studies have contributed important information to our understanding of postpartum changes in pelvic floor support,[20–28] all except two are limited in that POP was only assessed at a single time-point after deliver.[22,23] Our study is among the few (25) that provide information about short-term and long-term effects of labour and route of delivery on pelvic floor support to determine if and when recovery of pelvic floor support structures occurs over long periods of time.

The other strengths of our study include the 100% compliance rate at all time-points and the use of a homogeneous population of Asian women. The former eliminated the possible selection bias sourced from loss to follow up and the latter reduced the racial, ethnic and socio-economic variations that may have otherwise biased our findings. Although the age of women in our study is consistent with national data (average age for first-time mother 26.6 years),[29] it is difficult to know if these findings are generalisable to a more diverse population of women because it is a single-centre study. Multi-centre studies in more diverse populations are warranted.

One of the major limitations of our study was the lack of objective measures of prolapse symptoms or assessments of the impact of POP on quality life. At the time of data collection, quality of life measures validated in Mandarin were not available. Similar degrees of change in POPQ point measurements were seen in a previous study and were associated with worsening prolapse symptom and bother scores after vaginal delivery.[25] For the women in our cohort, it remains unclear whether or not the changes in pelvic floor support after TOL result in subjective symptoms. Future studies that include validated symptom measures of POP can help to elucidate our understanding of the natural history of symptomatic POP after TOL.

Another limitation is that the same gynaecologist performed all of the examinations. The affects of this are probably limited because the POPQ has been proven reliable with good inter-examiner and intra-examiner correlations reported.[30] At our institution approximately 80% of women who delivered vaginally received a mediolateral episiotomy, which was easily, identified at the postpartum visits. This made it impossible to blind the examiner to the mode of delivery. Although this could have introduced bias, this was probably limited, because the examiner was blinded to the previous POPQ measurement at each subsequent follow-up visit. Additionally, although performance of an episiotomy may have contributed to the injury seen in the pelvic floor in TOL, the most pronounced prolapse in this group was along the anterior wall in most of the women studied.

Interpretation

Incomplete recovery of pelvic organ support in nulliparous women defined using objective measures following TOL compared with caesarean delivery has only been reported in five peer-reviewed publications.[21,22,24,25,28] The rates of

POP ranged from 33 to 79% for women evaluated at various time-points between 6 weeks and 1 year postpartum. Importantly, by evaluating the pelvic floor at several time-points after delivery, we were able to evaluate the effect of time on POP outcome. Our work suggests that the time of evaluation after delivery may be an important factor and may explain the differences in the degree of POP observed in other studies.

For most women, the initial postpartum examination is traditionally scheduled at 6–8 weeks after parturition, during which time the reproductive tract, as well as the rest of the body, is believed to return to the non-pregnant state. Our results help to shed light on the dynamic changes that continue to occur up to 1 year after a nulliparous labour and delivery. Our findings indicate that continued changes occur in the pelvic floor from 36–38 weeks of gestation to 1 year postpartum, and suggest that the process by which the reproductive tract returns anatomically to a normal non-pregnant state after labour and delivery is not completed at the established 6-week postpartum time-point. This is also consistent with data from Tunn et al.[31] that suggests that connective tissue and pelvic floor muscle contractility takes up to 6 months to completely recover after parturition.

Continued long-term observation and tissue evaluation are essential to understanding the underpinning of pelvic floor laxity and POP development following UCD and TOL.

Our study also identified alterations in pelvic support that occurred before delivery and were most pronounced during the third trimester of pregnancy. This is consistent with findings of other authors.[20,21] Our results indicated that POP during the third trimester of pregnancy influences postpartum POP. Understanding the factors that contribute to third-trimester POP may help to elucidate preventive strategies for POP. Additionally, our data suggest that third-trimester POPQ examinations may be better suited to serve as baseline examinations for research studies evaluating longitudinal changes in POP postpartum.

Our data are consistent with other reports that have shown higher BMI as a risk factor for POP.[28] Although a higher NBW was protective in our study, this result should be interpreted with caution as there was a trend for UCD to have larger babies ($P = 0.13$). Additionally, although smoking has been reported to have a protective effect on POP,[7] the small population of smokers in our cohort ($n = 6$) suggests that the correlation between smoking and POP risk reduction probably occurred by chance.

According to Hill's criteria,[32] when there is a strong, consistent, specific and temporal association with a biological gradient, and a plausible and coherent outcome that can be detected experimentally, one must entertain the concept of causation rather than association. Our data along with those of others corroborate these tenets, providing strong evidence that TOL causes POP. This is particularly important given the robust effect size in our study.

Conclusion

The choice between caesarean section and TOL is complex, involving both maternal and neonatal factors with short-term and long-term implications. Our data suggest that factors unique to labour and delivery prevent normal pelvic floor remodelling and recovery that protect against sustained pelvic floor relaxation. It is essential to direct future research towards determining to what extent obstetric exposures affect changes over time in symptom burden and anatomic support. These data will be useful to women and their obstetric providers as they weigh childbirth options.

Disclosure of interests

The authors did not report any potential conflicts of interest.

Contribution to authorship

YC conceived the idea for this paper, collected the data and performed the data analysis, wrote the first draft and edited subsequent drafts of the manuscript. FL performed the data analysis, and provided important intellectual content for the manuscript; XL, JC and CC participated in data collection and management and provided important intellectual content for the manuscript; MKG assisted with analysis and interpretation of data, revised the manuscript for intellectual content and language. All authors approved the final version of the manuscript.

Details of ethics approval

The procedures used during the study were in accordance with the guidelines of the Declaration of Helsinki on human experimentation and with the Good Clinical Practice guidelines, and were justified by their potential diagnostic value. The Institutional Review Board of the Third People's Hospital, Wenzhou Medical College in China approved the study protocol on 20 January 2009. Women provided written informed consent before any assessment and gave specific permission for personal health information to be used for research purposes.

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