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Abstract

Objectives: Birth tears are a common complication of vaginal childbirth. We aimed to evaluate the outcomes of birth tears first by comparing the mode of vaginal birth (VB) and then comparing different vacuum cups in instrumental VBs in order to better advise childbearing women and obstetrical professionals.
Methods: In a retrospective cohort study, we analyzed nulliparous and multiparous women with a singleton pregnancy in vertex presentation at ≥37 + 0 gestational weeks who gave birth vaginally at our tertiary care center between 06/2012 and 12/2016. We compared the distribution of tear types in spontaneous births (SBs) vs. vacuum-assisted VBs. We then compared the tear distribution in the vacuum group when using the Kiwi Omnicup or Bird's anterior metal cup. Outcome parameters were the incidence and distribution of the different tear types dependent on the mode of delivery and type of vacuum cup.
Results: A total of 4549 SBs and 907 VBs were analyzed. Birth tear distribution differed significantly between the birth modes. In 15.2% of women with an SB an episiotomy was performed vs. 58.5% in women with a VB. Any kind of perineal tear was seen in 45.7% after SB and in 32.7% after VB. High-grade obstetric anal sphincter injuries (OASIS) appeared in 1.1% after SB and in 3.1% after VB. No significant changes in tear distribution were found between the two different VB modes.
Conclusions: There were more episiotomies, vaginal tears and OASIS after VB than after SB. In contrast, there were more low-grade perineal and labial tears after SB. No significant differences were found between different vacuum cup systems, just a slight trend toward different tear patterns.

Keywords: anal sphincter; assisted vaginal birth; birth tears; lacerations; vacuum; ventouse; perineal tears.

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Introduction

Birth tears are a common complication of vaginal childbirth and can have both short- and long-term implications [1–9]. Obstetricians and midwives worldwide focus on the minimization or prevention of such trauma [10]. The main focus hereby is on obstetric anal sphincter injuries (OASIS), as they have the strongest negative impact on women's health within the different types of visible birth tears [3, 11]. Currently, there is limited literature regarding the association between other types of birth tears, such as vaginal, labial or paraurethral lacerations, and the mode of vaginal delivery, especially when comparing different vacuum cups in instrumental-assisted vaginal births (VBs). Indeed, those lacerations do not have an impact on fecal incontinence as OASIS have, but can also negatively affect women's quality of life in the form of sexual disorders, pain, infection and others [2, 4]. Pregnant women these days are concerned about their well-being and claim for elucidation and the best medical treatment. Health professionals involved in VBs need to be able to inform their patients about possible consequences of the different modes of VB and to decide which mode and device to use best.

Therefore, the objective of our study was to evaluate first the distribution of birth tears in spontaneous VBs compared to vacuum-assisted births and second the tear distribution in vacuum-assisted births compared by two different types of vacuum cups.

Materials and methods

In a retrospective cohort study, we evaluated all women with VBs between 6/2012 and 12/2016, who gave birth in our tertiary care hospital to a singleton in vertex presentation at ≥37 + 0 gestational weeks (GW) and who were at least 18 years of age. We excluded multiple pregnancies, preterm deliveries, fetal transverse or breech positions and fetal malformations. The study has complied with all relevant national regulations and is in accordance with the Declaration of Helsinki regarding the ethical conduct of research involving human subjects, and has been approved by the Ethical Board of the district (KEK-ZH-Nr. 2016-02079).

We extracted the maternal, fetal and obstetrical data out of our computerized in-house data system (Perinat 6). Obstetrical care was standardized in our hospital during the study period according to in-house, national and international guidelines [12–15]. Epidural anesthesia was applied on patient's request or upon medical advice. The choice of type of vacuum system was upon the obstetrician's preference. Either a plastic, hand-held vacuum system (Kiwi Omnicup, Clinical Innovations, LLC, South Murray, UT, USA) or the conventional metal cup system (Bird's anterior cup, Medela AG, Baar, Switzerland or Menox AB, Goteborg, Sweden) was used.

Birth tears were evaluated by the attending obstetrician after every single birth and were classified in words and recorded graphically as described earlier by our group [10]. Classification of birth tears was hereby based on the obstetric clinical data definitions by the American College of Obstetricians and Gynecologists (ACOG) and were classified into vaginal tears, labial tears, perineal tears grade 1–4, periurethral tears, cervical tears and episiotomies [7].

The outcomes were the distribution of the tear types between the different modes of VB (spontaneous vs. vacuum-assisted birth) and between the two different vacuum cup groups in vacuum-assisted births (Kiwi Omnicup vs. metal cup). Statistical analysis was performed using the statistical software package SPSS version 25.0 (IBM SPSS, Armonk, NY, USA). Student's *t*-test was used to compare continuous variables and chi-square (χ^2) test was used for categorical variables. First, a univariate analysis was performed to evaluate the association between tear types and mode of delivery and type of vacuum cup, respectively. A multivariate analysis was performed, if parameters were statistically significant on univariate analysis. The level of significant difference was set at $P < 0.001$ due to the large cohort.

Results

During the study period, 5456 births were included in the analysis with 4549 (83.4%) spontaneous VBs and 907 (16.6%) vacuum-assisted births. Within the group of spontaneous births (SBs), 2053 (45.1%) women were nulliparous and 2497 (54.9%) multiparous, whereas within the group of vacuum-assisted births, 795 (87.7%) were nulliparous and 111 (12.3%) multiparous. The characteristics of women after spontaneous and vacuum-assisted births are presented in Table 1.

Table 1: Characteristics of the women after spontaneous and vacuum-assisted births.

	Spontaneous birth (n = 4549)	Vacuum-assisted birth (n = 907)	Univariate analysis P-value	Multivariate analysis P-value
Age, years	31.7 ± 5.2	31.9 ± 5.0	0.191	
Parity	1.8 ± 0.9	1.2 ± 0.5	0.000[a]	0.000[a]
Nulliparous	2053 (45.1)	795 (87.7)		
Multiparous	2496 (54.9)	112 (12.3)		
Gestational age, weeks	39.8 ± 1.1	40.0 ± 1.1	0.000[a]	0.084
BMI, kg/m^2	22.7 ± 4.2	22.0 ± 3.7	0.000[a]	0.097
Fetal weight > 4000 g	366 (8.0)	54 (6.0)	0.016	
Fetal head circumference >36 cm	468 (10.3)	192 (21.2)	0.000[a]	0.000[a]
Fundal pressure	199 (4.4)	66 (7.3)	0.000[a]	0.000[a]
Epidural anesthesia	1486 (32.7)	660 (72.8)	0.000[a]	0.000[a]
Fetal malposition	132 (2.9)	61 (6.7)	0.000[a]	0.000[a]
Pathologic second stage fetal heart tracing	276 (6.1)	348 (38.4)	0.000[a]	0.000[a]
Tear types				
Intact	1189 (26.1)	34 (3.7)	0.000[a]	0.667
Episiotomy	693 (15.2)	531 (58.5)	0.000[a]	0.000[a]
Perineal tear grade 1	871 (19.1)	91 (10.0)	0.000[a]	0.116
Perineal tear grade 2	1161 (25.5)	178 (19.6)	0.000[a]	0.022
Perineal tear grade 3/4	48 (1.1)	28 (3.1)	0.000[a]	0.019
Vaginal tear	1067 (23.5)	316 (34.8)	0.000[a]	0.000[a]
Labial tear	727 (16.0)	85 (9.4)	0.000[a]	0.000[a]
Paraurethral tear	143 (3.1)	12 (1.3)	0.001	
Cervical tear	9 (0.2)	7 (0.8)	0.010	

Values are presented as mean ± standard deviation (SD) or n (%); [a]Significant difference with P-value <0.001.

There is evidence of significance at a level of <0.001 between the two birth mode groups for several baseline factors and tear types in univariate analysis. Women after SB were more often multiparous, of lower gestational age, of higher body mass index (BMI), had fetuses with a smaller head circumference and less often in malposition, had less often a pathologic cardiotocogram (CTG) in the second stage of labor and fundal pressure and epidural anesthesia were less often applied to them. No evidence for significant differences was found for maternal age and fetal weight.

As more than one tear type can occur at the same time, the sum of the single tears exceeded the number of women and the rate of tears exceeded 100%. Women after SB and women after vacuum-assisted birth significantly differed regarding all types of tears except for paraurethral and cervical tears.

Only 3.7% of all women in the vacuum-assisted birth group did not show any birth tear. Compared to that the rate of an intact genital body in women after SB was with 26.1% almost seven times higher. Besides, episiotomies, high-grade perineal tears and vaginal tears less often occurred in women after SB. In contrast, women after vacuum-assisted births showed less often low-grade perineal tears and labial tears. The rate of high-grade perineal tears was 1.1% after SB and 3.1% after vacuum-assisted birth.

In multivariate analysis, the remaining factors associated with SB were nulliparity and labial tears, whereas multiparity, fetal head circumference >36 cm, epidural anesthesia, fetal malposition, fundal pressure, pathologic fetal heart tracing, episiotomies and vaginal tears were associated with vacuum-assisted births.

For women after vacuum-assisted birth with different vacuum cups, no such differences could be found. The characteristics of the 907 women with vacuum-assisted births according to the two types of vacuum cups are presented in Table 2.

In 357 women (39.4%), the Kiwi Omnicup was used, whereas in 550 women (60.6%), the metal cup was applied.

There were no significant differences in the baseline characteristics and tear types between the two groups of different vacuum cups, except for the rate of epidural anesthesia with higher rates in the metal cup group and the fetal head position at the time of vacuum extraction. Significantly more often a metal cup was used when the fetal head was high (Hodge's plane +1) and the Kiwi Omnicup more often chosen when the fetal head was already quite low (Hodge's plane +3 or +4).

Nonetheless, there seems to be a trend toward fetuses of higher birth weight and head circumference in the metal cup group. Furthermore, there is a trend to use a metal cup when the indication for vacuum extraction is labor arrest and to end the birth process by using a Kiwi Omnicup when there is an abnormal fetal heart rate tracing.

Discussion

Distribution of tear types between spontaneous and vacuum-assisted births

The here presented distribution of the different tear types in SB and vacuum birth is in accordance with the literature [4, 5, 8, 9, 16, 17]. We know that tear patterns do differ between births of different parities and that they are associated with sustained tear patterns of previous births [18]. Therefore, some of the differences in tear distribution between spontaneous and vacuum births in our study will be explained just by parity. Additionally, different maternal, fetal and obstetrical parameters are associated with different birth tear patterns in women of differing parity and according to the birth mode and rate of episiotomies [16–21]. The more episiotomies were performed, the less perineal, labial and paraurethral tears were found, as could be seen in our data. This can be explained by the fact that by performing an episiotomy a widening of the introitus of the vulva was achieved with less resistance of tissue against the expanding forces of the fetal head and body and therefore with less spontaneous trauma of the surrounding tissue. Therefore, it is understandable that in the cases with episiotomies less other tear types occurred. In our cohort, women with vacuum-assisted births had much more often an episiotomy and therefore less often other birth tear types compared to the women with SBs. On the one hand, the higher rate of episiotomies in the vacuum group can be explained by the widespread use of episiotomies in vaginal-operative births in general as kind of standard care with this procedure to avoid OASIS. On the other hand, vacuum extractions are much more likely performed in births with expected fetal compromise, so episiotomies are additionally performed to the vacuum maneuver in order to fasten the birth process.

However, the differing distribution of tear types between the women with SBs and vacuum births might mainly be due to the differing baseline characteristics of the two groups. Women with vacuum births were more likely to be nulliparous, had more often an epidural, carried fetuses with a bigger head circumference and with a head in malposition and showed more often a

Table 2: Characteristics of the women with vacuum-assisted births according to the two types of vacuum cups.

	Kiwi Omnicup (n = 357)	Metal cup (n = 550)	Univariate analysis P-value	Multivariate analysis P-value
Age, years	32.3 ± 5.2	31.7 ± 4.8	0.086	
Parity	1.2 ± 0.6	1.1 ± 0.4	0.058	
Nulliparous	306 (85.7)	489 (88.9)		
Multiparous	51 (14.3)	61 (11.1)		
Gestational age, weeks	40.0 ± 1.2	40.0 ± 1.1	0.800	
BMI, kg/m^2	21.8 ± 3.4	22.2 ± 3.8	0.175	
Fetal weight > 4000 g	13 (3.6)	41 (7.5)	0.021	
Fetal head circumference > 36 cm	56 (15.7)	136 (24.8)	0.001	
Fundal pressure	20 (5.6)	46 (8.4)	0.150	
Epidural anesthesia	220 (61.6)	440 (80.0)	0.000[a]	0.000[a]
Fetal malposition	18 (5.0)	43 (7.8)	0.135	
Pathologic second stage cardiotocogram	149 (41.7)	199 (36.2)	0.108	
Indication for vacuum extraction			0.017	
Labor arrest	138 (38.7)	271 (49.3)		
Abnormal fetal heart rate	182 (51.0)	233 (42.4)		
Vaginal bleeding	4 (1.1)	3 (0.5)		
Insufficient maternal pushing	18 (5.0)	19 (3.5)		
Contraindication for pushing	2 (0.6)	1 (0.2)		
Fetal head position (Hodge's plane)			0.000[a]	0.000[a]
+1	67 (18.8)	181 (32.9)		
+2	199 (55.7)	307 (55.8)		
+3	66 (18.5)	42 (7.6)		
+4	14 (3.9)	2 (0.4)		
Number of vacuum tractions			0.043	
1	54 (15.1)	65 (15.2)		
2	148 (41.5)	207 (37.6)		
3	113 (31.7)	211 (38.4)		
4	25 (7.0)	53 (9.6)		
5	12 (3.4)	9 (1.6)		
Tear types				
Intact	14 (3.9)	20 (3.6)	0.479	
Episiotomy	200 (56.0)	331 (60.2)	0.120	
Perineal tear grade 1	41 (11.5)	50 (9.1)	0.145	
Perineal tear grade 2	76 (21.3)	102 (18.5)	0.176	
Perineal tear grade 3/4	10 (2.8)	18 (3.3)	0.424	
Vaginal tear	117 (32.8)	199 (36.2)	0.163	
Labial tear	34 (9.5)	51 (9.3)	0.493	
Paraurethral tear	6 (1.7)	6 (1.1)	0.317	
Cervical tear	3 (0.8)	4 (0.7)	0.567	

Values are presented as mean ± standard deviation (SD) or n (%); [a]Significant difference with P-value <0.001.

pathologic fetal heart rate tracing. These parameters are known to lead more frequently to genital tears including severe lacerations and are an expression for a more complicated birth process. Therefore, the vacuum maneuver itself might not be consecutively the main reason for the sustained tears, but somehow contributes to their occurrence. One has to keep in mind that the different mentioned impact factors are not completely independent from each other. For example, we all know that in births with higher fetal head circumference and with the fetal head in malposition more often an epidural will be applied and the birth process will be slower, so that in the end, it is more likely to end up in vacuum-assisted births. Besides, in births with a pathologic fetal heart rate tracing, it is much more likely to accelerate the birth process by applying an episiotomy and use vacuum extraction. It is best known that the correct technique of perineal support and vacuum extraction is a component of a differing tear distribution and an important part of reducing birth trauma, especially of OASIS [9, 11, 22–25]. Consequently, the technique of perineal support and vacuum extraction itself needs further investigation in the future, in addition to other impact factors, such as "maternal anatomy and tissue condition" and "biomechanics of the birth canal".

Distribution of tear types between the different vacuum cup systems in vacuum-assisted births

Regarding the different vacuum cups and systems used for vaginal-operative births, our study shows no significant differences in tear distribution between the Kiwi Omnicup and the classical metal cup.

When comparing maternal and neonatal parameters between the different vacuum cups, the metal cup was significantly used more frequently in women with epidural anesthesia and when the fetal head was still high (Hodge's plane +1). Epidural anesthesia is often applied when the birth process is slow allowing the mother's body to relax and aiming for the cervix to further dilate and the fetal head to descend. Epidural anesthesia and a high fetal head are both signs for a slower birth process or labor arrest, respectively. A metal cup might preferably be used when a difficult vacuum is expected and stronger forces of traction might be necessary to be applied.

On the other hand, a Kiwi Omnicup was significantly more often used when the fetal head was already low (Hodge's plane +3 and +4) as kind of a "lift out" vacuum when the vacuum device does not require as much force.

Additionally, there was a non-significant trend toward higher fetal weight, larger head circumference and labor arrest as an indication for a vacuum-assisted birth in the metal cup group, which all reflect a tendency toward a slower birth process and a more difficult extraction of the fetus. A trend of using the Kiwi Omnicup was recognized when there was an abnormal fetal heart rate tracing as a Kiwi Omnicup can be applied and used much quicker than a metal cup. Therefore, the trend in the different tear distributions between the two cup groups might be due to different indications for choosing the metal or the Kiwi Omnicup. Metal cups in our institution are much more likely to be chosen in births with higher expected fetal weight and head circumference, in fetuses with a bigger caput succedaneum, weak uterine contractions or a narrow birth canal in relation to the expected size of the fetus.

One has to keep in mind that the correct placing of the cup onto the fetus' head over the flexion point is essential to reduce both maternal and neonatal morbidity during a vacuum-assisted VB. Regardless of the head's position, the obstetrician must be able to find the flexion point and correctly position the cup as Vacca has described this in detail [26]. It is mandatory to extract the fetal head in flexion and pulling forces on the flexion point do flex a deflected head and do correct asynclitism. Furthermore, direction of pulling along the axis of the pelvis is essential for a successful vacuum-assisted delivery. Those factors are inevitable parameters to reduce neonatal and maternal complications. Documentation of the location of the vacuum cup is performed at our institution by taking photos of the infant's head and those photos are stored in our in-house computerized data system. With the introduction of the documentation, colleagues at our institution were able to demonstrate a reduction in maternal morbidity [27]. More often, an intact genital body was seen and fewer episiotomies were performed without changing the occurrence of the rate of OASIS. It can be assumed that the obstetricians felt more closely observed by the photo documentation and thus their behavior was influenced toward a better placement of the vacuum device (the so-called Hawthorne effect). This could explain the reduced maternal morbidity. Unfortunately, we were not able to include the placing of the cup in this retrospective analysis without violating ethical standards. Hence, we cannot validate with our study that the correct placement reduces the occurrence of birth tears. This could be the subject of a future prospective study.

A limitation of our study is the retrospective character without randomization of the women with vaginal-operative births into the two different cup groups. Very few prospective randomized trials exist that compare the Kiwi Omnicup with any other kind of vacuum system, and all of them just focus on a few single tear types, which are episiotomies and perineal tears. Mainly, no data are given about the other tear types, such as vaginal, labial, paraurethral and cervical tears.

In the prospective randomized trial by Groom et al. regarding the safety of the use of Kiwi Omnicup vs. metal cup, an episiotomy rate of almost 62% was registered for the Kiwi Omnicup and 60% for the metal cup [28]. Besides, they found OASIS rates of 4.8% for the Kiwi Omnicup and 3.5% for the metal cup [28]. All of the values are higher than in our cohort. Another randomized prospective trial for vacuum-assisted births, using either the Kiwi Omnicup or the Malmstrom's metal cup, performed an episiotomy as standard care in all women [29]. In addition to these episiotomies, 3.5% of women in the Kiwi Omnicup group had a perineal tear and 3.8% in the metal cup group. No comparison can be made to our study, as we did not perform episiotomies as a standard procedure and no data regarding other tears are presented. Another randomized prospective study by Attilakos et al., comparing a group of women with the Kiwi Omnicup with a group of women with either a metal or a silastic cup, found rates for episiotomy of 47% vs. 52%, for intact perineum of 12% vs. 11%, of low-grade perineal tears of 81% each and for OASIS of 7% vs. 8% [30]. In the prospective randomized trial by Mola et al., the Kiwi Omnicup was compared to the Bird's anterior or posterior cup in 100 women each [26]. Intact perineum was found in 33% vs. 38%, low-grade perineal tears in 5% vs. 2%, OASIS in 3% vs. 1% and episiotomies in 62% vs. 60%, all being not statistically significant. None of the mentioned studies presented data for the other tear types.

Further studies were either retrospective as ours or did not compare different vacuum cup systems.

In the study by Siggelkow et al., retrospectively comparing a small cohort of vacuum-assisted births with either the Kiwi Omnicup or a metal cup, 61% episiotomies, 19% second-degree perineal tears and 16% high-grade perineal tears were found in the Kiwi Omnicup group vs. 76%, 8% and 10% in the metal cup group, respectively [31]. In the study by Turkmen, vacuum-assisted births with the Kiwi Omnicup were compared to those with the Malmstrom's metal cup [32]. They found 34% of episiotomies in the Kiwi Omnicup group vs. 55% episiotomies in the metal cup group, which was statistically significant, 50% vs. 48% vaginal tears, 31% vs. 23% perineal tears grade 1–4 and 8% vs. 20% high-grade perineal tears. Another study by Hayman et al. compared the Kiwi Omnicup with a mixed vacuum cohort of silastic and metal cups in nulliparous and multiparous women [33]. They found comparable data with 11.5% intact perineum, 16.7% perineal tears grade 1, 25.6% perineal tears grade 2, 3.8% high-grade perineal tears and 42% episiotomies. There was no differentiation between the silastic and the metal cup.

Two other studies just reported the maternal tear rates after use of the Kiwi Omnicup without comparing them to other cup systems. In a study by Baskett et al., the tear rates in women after vacuum-assisted birth with the Kiwi Omnicup was distributed as follows: 35.6% intact, 15.5% perineal tears grade 1, 38.3% perineal tears grade 2, 10.6% high-grade perineal tears and 48% episiotomies [34]. Compared to them, we have lower rates of all kinds of perineal tears, especially high-grade perineal tears, but higher rates of episiotomies, which could explain those different results. In the study by Vacca again only Kiwi Omnicup vacuums were evaluated. They counted 15% of intact perineum, 55.5% of episiotomies, 27% of low-grade and 12% of high-grade perineal lesions [35]. Again, no data for the other tear types were provided in all the aforementioned studies.

Hence, regarding birth tears, none of the two vacuum systems in our study excels the other, so the obstetrician can choose the cup upon his or her preference and skills. Nevertheless, the cups need to be carefully applied, especially the metal cup, in order to avoid iatrogenic lacerations.

Conclusions

Birth tear incidence and distribution differed between different modes of VB. There were more episiotomies, vaginal tears and OASIS after vacuum than after SB. In contrast, there were more low-grade perineal and labial tears after SB. No significant differences were found between the different vacuum cup systems. Hence, regarding birth tears, none of the two vacuum systems excels the other, so the obstetrician can choose the cup upon his or her preference and skills. However, the described differing characteristics and tears between the birth mode groups might be an expression of a differing biomechanical birth process in spontaneous and vacuum-assisted births. Both the technique of perineal support and vacuum extraction need closer investigation in the future, as well as other impact factors, such as “maternal anatomy”, “maternal tissue condition” and “biomechanics of the birth canal” as an expression of the necessary adaptations during birth.

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