Rotational forceps versus manual rotation and direct forceps: a retrospective cohort study

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Condensation: Rotational forceps are more effective than manual rotation and direct forceps for achieving vaginal birth, but associated with higher rate of shoulder dystocia.

Short title: Rotational forceps versus manual rotation and direct forceps

ABSTRACT (WORD LIMIT 500)

Background

Rotational forceps (RF) and manual rotation (MR) followed by direct forceps are two techniques used in the management of malposition of the fetal head in the second stage of labor; there is debate regarding their relative utility.

Objective

To compare the effectiveness and safety of rotational forceps with manual rotation followed by direct forceps, for management of fetal malposition at full dilatation.

Study Design

Retrospective cohort study, set in a single tertiary obstetric unit with >6000 births per year. All attempted RF births over 21 months (Jan 2010 – Sept 2012) and matched chronologically sequential attempted MRs and direct forceps births (2:1 by number). Total of 302 births, 104 by RF, 208 by MR followed by direct forceps. Univariable and multivariable approaches were used for statistical analysis. The primary outcome measure was successful vaginal birth.

Results

The rate of successful vaginal birth was significantly higher with RF than with MR followed by direct forceps (88.5% vs 82.2%, RR 1.17, 95 % CI 1.04 - 1.31, p = 0.017). Births by RF were associated with a significantly higher rate of shoulder dystocia (19.2% vs 10.6%, RR 2.35, 95% CI 1.23 - 4.47, p = 0.012), but not of neonatal injury (temporary or permanent). There was no evidence of statistically significant difference in all other maternal and neonatal outcomes between the two modes of birth.

Conclusions

The use of RF was associated with a significantly higher rate of successful vaginal birth, but also of shoulder dystocia, compared to attempted MR (to be followed by direct forceps). Accoucheurs should be trained in both techniques.

Introduction

Rotational forceps (RF) and manual rotation (MR) followed by direct forceps are both used to perform rotational operative vaginal birth. In the absence of strong evidence from randomised controlled trial to guide best practice, there remains debate regarding the most appropriate method for safe and effective birth in the presence of malposition.

The use of RF to achieve vaginal birth has been advocated by various professional bodies [1]. Higher rates of complications, such as delayed onset of respiration, birth trauma or neonatal irritability, have been reported following the use of RF ([2],REF, REF…). However, most data come from small old cohort studies without appropriate control groups of babies delivered with other rotational operative birth method. Nonetheless, fear of increased complication rates compounded by a lack of supervised training to achieve independent competent practice, has led large numbers of current day obstetricians to discontinue or never acquire skills in the use of RF [3,4]. Renewed interest in the safety and efficacy of RF is emerging [3,5-8] The use of RF may be associated with high rates of successful vaginal birth and comparable or lower rates of adverse outcomes than alternative modes of birth [9] [10] [11] [12] [13].

We conducted a retrospective cohort study to determine differences in maternal and neonatal outcomes between RF and MR followed by direct forceps, in a unit with regular interprofessional training in birth emergencies.

MATERIALS & METHODS

This was a retrospective cohort study between January 2010 and September 2012 in a single tertiary-level maternity unit in Bristol, UK with more than 6000 births per annum. Approval was given by the Clinical Governance Department (No: 23849).

All rotational operative births conducted in this hospital were performed or directly supervised by senior obstetricians qualified to perform mid-cavity rotational operative vaginal birth (OVB) independently. Obstetricians with ≥4 years training (Speciality Trainee (ST) 4+) would usually perform MR followed by direct forceps independently. All attempts at RF were either supervised by a consultant, or undertaken independently by a senior trainee (ST6-7) who had previously been assessed as competent by the consultant team to perform RF without supervision.

All births conducted in the study period were assessed for eligibility. Eligible participants were women who had singleton, cephalic pregnancies with persistent malposition at full cervical dilation (occipito-transverse (OT) or occipito-posterior (OP)), and attempted RF or attempted MR followed by direct forceps births. Every attempted RF birth and the next two sequential MR followed by direct forceps attempts were extracted in order to obtain a comparative cohort frequency-matched 1:2.

Demographic, clinical variable factors and outcomes were extracted from maternity paper notes and electronic medical records (EuroKing Software, Chertsey, UK). Neonatal data was extracted from the Badger electronic database (Clevermed Ltd, Edinburgh, UK).

Information on the following maternal characteristics were collected: maternal age, body mass index (BMI) (<25, 25 to 30, ≥30 kg/m^2), parity, history of previous Caesarean or vaginal birth, length of gestation (<37 weeks, ≥37 weeks), duration of first and second stage (minutes), indication for birth (presumed fetal compromise, delay in 2nd stage), position of fetal head (right (R) occipito-anterior (OA), ROT, ROP, OP, left (L) occipito-posterior, LOT, LOA, OA), station of fetal head (at ischial spines, +1cm below ischial spines, +2cm below ischial spines), degree of moulding (none, +, ≤++), degree of and caput (none, 1cm, 2cm) , analgesia (epidural block, spinal block, pudendal block), baby birth weight (<4 Kg, ≥4 Kg), grade of operator (ST 1 to 2, ST 3, ST 4 to 5, ST 6 to 7, consultant), and seniority of supervisor if applicable (ST 6 to 7, consultant).

The primary outcome was successful vaginal birth. A birth ultimately performed with a Caesarean section was considered as unsuccessful vaginal birth. Secondary maternal outcomes were: diagnosis of anal sphincter injury, postpartum haemorrhage (PPH, >1litre vs ≤1litre), anaemia (Hb < 105g/dl vs ≥105g/dl) within 24 hours following birth, occurence of maternal sepsis, maternal length of stay in hospital(days). Secondary neonatal outcomes were: umbilical artery or vein pH (≥7.10, <7.10), Apgar score at 1 min (≥3, <3), Apgar score at 5 min (≥7, <7), Apgar score at 10 min (≥7, <7), occurence of shoulder dystocia, jaundice, transient tachypnoea of the newborn (TTN), sepsis, seizure, any neonatal injury (including cephalohaematoma, retinal haemorrhage, facial injury and bony injury, and any nerve injury), admission to neonatal intensive care unit, and length of admission (days).

Frequency and percentage of demographic, clinical variable factors, maternal and neonatal outcomes were described and tabulated by rotation technique. Log-binomial regressions were used to derive relative risk and compare the prevalence rates between the two rotation technique groups. The group difference in length of hospitalisation was investigated with an ordered logistic regression. Regressions were adjusted for maternal age, parity, BMI, length of gestation, first and second stage duration, supervisor grade, fetal position in-utero and birth weight. Comparison from unadjusted regression was reported when the frequency of the outcome of interest was low. Statistical significance <0.05 was considered as evidence of group difference. Analyses were performed using Stata® software, version 13 (StataCorp, College Station, Texas, USA). We used the STROBE guideline and checklist to report the study [14].

RESULTS

The sample comprised 312 women who had attempted rotational OVBs by experienced obstetricians during the 21-month study period; 104 attempted RF births and 208 attempted births by MR followed by direct forceps. There were no attempts to apply a second instrument to achieve a vaginal birth in this study if OVB with the first instrument failed. Mean maternal age was 29.6 (standard deviation (SD) 5.9 years), mean BMI was 24 (SD 4.5), 86% of women had not had a previous vaginal birth, and 50% were delivered due to a prolonged second stage of labour. All demographic data are summarised in Table 1.

The successful vaginal birth rate was 88.5% for RF and 82.2% for MR followed by direct forceps. This difference was significant following adjustment (RR 1.17, 95% CI 1.02 – 1.27 p = 0.017).

Births by RF were associated with a higher rate of shoulder dystocia (19.2% vs 10.6%, RR 2.35, 95% CI 1.23 - 4.47, p = 0.009), but none of the babies in the study sustained a birth injury (temporary or permanent) secondary to dystocia.

No evidence of difference in anal sphincter injury rates was found between RF births and MR births (9.6% in RF, 5.8% in MR, $p = 0.08$).

There were no significant differences in all other adjusted maternal or neonatal outcomes by mode of birth – detailed in Tables 2 and 3 respectively. Where patient numbers were not sufficient to conduct comparisons, no statistical interpretation is given and data are presented for descriptive purpose in Tables 2 and 3. All outcomes are given unadjusted in Supplementary Table 4

COMMENT

This study shows that rotational forceps are more successful than MR followed by direct forceps for achieving successful rotational operative vaginal birth.

This difference in effectiveness has clinical implications. Increased adverse outcomes for mothers and babies occur when sequential instruments are used for vaginal birth, such as increased anal sphincter trauma or increased risk of umbilical artery pH <7.10[15]. Similarly increased rates of complications are observed when birth is achieved by Caesarean after failed instrumental attempt or during the second stage of labour [10], [16]. Training in the use of rotational forceps might help prevent these complications, however this study shows potential caveats.

This study is the first in the published literature to demonstrate a statistically significant difference in shoulder dystocia rates between RF and MR followed by direct forceps. We note that these rates are higher than those quoted in recent studies of rotational birth. Tempest et al. reported shoulder dystocia risk of 6.2% following RF and Aiken et al. reported a rate of 2.7% following pooled RF and rotational ventouse

[10,12,13]. Finally, Bahl et al. reported a shoulder dystocia rate of 6.2% following RF and 4.9% following MR followed by direct forceps. The reason for the higher rate of shoulder dystocia in our study is not clear and may be related to a lower threshold for diagnosing shoulder dystocia. The unit in which this study was conducted has reported a 3.3% rate of shoulder dystocia in all vaginal births over a three-year period including this study (2009 to 2012) [17], which is substantially higher than other comparable units – in a unit of similar size in 2004 to 2008, Walsh et al. found a 1.7% rate of shoulder dystocia [18]. We found no adverse neonatal neurological outcomes associated with shoulder dystocia, contrary to other studies; Tempest et al. reported 10 cases of temporary Erb's Palsy and Burke et al. reported 1 case of permanent Erb's Palsy [9] [10]. This combination of a higher rate of shoulder dystocia but lower rates of resultant nerve injury may reflect regular training in shoulder dystocia, which has been practiced in the studied unit since 2002 [19,20]. It could also reflect overdiagnosis of innocuous cases that would have had good outcomes regardless of the manoeuvres employed by the attending staff [18]. However, it has been shown that in maternity units with embedded practical teaching in the management of obstetric emergencies, shoulder dystocia is better recognised and documented [21], better managed [19], and can be associated with zero rates of permanent brachial plexus injuries [17]. Importantly, the rates of anal sphincter injury were not significantly different and are comparable to other recent studies in this field [10-13,22,23].

The strengths of this study include that it includes all attempted RF births performed in a large obstetric unit with embedded practical training in operative birth and obstetric emergencies, and that all attempted rotational operative vaginal births were performed or directly supervised by a senior obstetrician able to perform these procedures independently.

A potential criticism is that the study was a retrospective cohort study with its inherent limitations. We have reduced the effects of confounding by adjusting for anticipated factors. Moreover, all exposures and outcomes were documented with standardised proformas to reduce measurement error.

Furthermore, the study only examined immediate complications of birth, and did not look at longer-term outcomes such as dyspareunia, prolapse, incontinence or subsequent fear of childbirth. These are important and should be taken into account in any discussion around OVB. Recent individual studies [9-13] have not been of sufficient size to allow comparison of rarer outcomes, such as retinal haemorrhage, cephalohaematoma or permanent neurological injury, and a recent meta-analysis did not consider complications individually but as a composite [24].

Whereas this study was not powered for rarer events such as facial nerve palsy, the cases described can contribute to the power of any future meta-analyses of outcomes in rotational OVB and have therefore been reported here.

There remains debate around the place of rotational forceps in modern obstetric practice. This study adds to other recent studies [9-11,13] [12], in quantifying the superior efficacy of RF over MR followed by direct forceps birth for malposition in the second stage of labour.

There remains reluctance to adopt RF as an accepted technique for rotational OVB. Junior obstetricians in particular need confidence and familiarity with the safe use of rotational forceps [26]. This could be learnt under the instruction of an experienced senior obstetrician in real cases [27].Simulation could also play an important role in beginning learning in a safe environment[28]; it has been shown to improve trainee use of direct forceps [29] and we hypothesise that the same improvement in use is likely to apply to rotational forceps as well. The safe use of rotational forceps might require a more important place in current obstetric curricula.

In conclusion, this study shows that both techniques, rotational forceps, and manual rotation followed by direct forceps, are effective and safe in experienced or supervised hands. The results confirm the superior effectiveness of rotational forceps and underline the importance of practical training, to ensure that effectiveness is accompanied by safety.

References

1. RCOG. *Operative Vaginal Delivery*. 2011:1-19.

2. Chiswick ML, James DK. Kielland's forceps: association with neonatal morbidity and mortality. *BMJ*. 1979;1(6155):7-9. doi:10.1136/bmj.1.6155.7.

3. Hardy C, Roberts R. The role of rotational forceps. *BJOG*. 2014;121(5):641-642. doi:10.1111/1471-0528.12603.

4. Meager C, Griffiths A, Penketh R. The use of Kielland"s forceps and obstetricians" anxiety trait. *J Obstet Gynaecol*. 2008;28(7):700-702. doi:10.1080/01443610802463629.

5. Ekechi CI. Rotational forceps. Is it safe? A re-evaluation of the role of rotational forceps: retrospective comparison of maternal and perinatal outcomes following different methods of birth for malposition in the second stage of labour. *BJOG*. 2014;121(5):644-644. doi:10.1111/1471-0528.12561.

6. Gale A, Siassakos D, Attilakos G, Winter C, Draycott T. Operative vaginal birth: better training for better outcomes. *BJOG*. 2014;121(5):642-643. doi:10.1111/1471-0528.12559.

7. Nash Z, Mascarenhas L, Nathan B. A re-evaluation of the role of rotational forceps: retrospective comparison of maternal and perinatal outcomes following different methods of birth for malposition in the second stage of labour. *BJOG*. 2014;121(5):641-642. doi:10.1111/1471-0528.12603.

8. Treharne I, Esegbona G, Bloomfield T. Rotational forceps training needs to be scaled up. *BJOG*. 2014;121(5):641-641. doi:10.1111/1471-0528.12602.

9. Burke N, Field K, Mujahid F, Morrison JJ. Use and Safety of Kielland's Forceps in Current Obstetric Practice. *Obstet Gynecol*. 2012;120(4):766-770. doi:10.1097/AOG.0b013e3182695581.

10. Tempest N, Hart A, Walkinshaw S, Hapangama DK. A re-evaluation of the role of rotational forceps: retrospective comparison of maternal and perinatal outcomes following different methods of birth for malposition in the second stage of labour. *BJOG*. 2013;120(10):1277-1284. doi:10.1111/1471-0528.12199.

11. Stock SJ, Josephs K, Farquharson S, et al. Maternal and Neonatal Outcomes of Successful Kielland's Rotational Forceps Delivery. *Obstet Gynecol*. 2013;121(5):1032-1039. doi:10.1097/AOG.0b013e31828b72cb.

12. Aiken AR, Aiken CE, Alberry MS, Brockelsby JC, Scott JG. Management of fetal malposition in the second stage of labor: a propensity score analysis. *Am J Obstet Gynecol*. 2015;212(3):355.e1-355.e7. doi:10.1016/j.ajog.2014.10.023.

13. Bahl R, Van de Venne M, Macleod M, Strachan B, Murphy DJ. Maternal and neonatal morbidity in relation to the instrument used for mid-cavity rotational operative vaginal delivery: a prospective cohort study. *BJOG*. 2013;120(12):1526-1533. doi:10.1111/1471-0528.12398.

14. Elm von E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: guidelines for reporting observational studies. *Lancet*. 2007;370(9596):1453-1457. doi:10.1016/S0140-6736(07)61602-X.

15. Murphy DJ, Macleod M, Bahl R, Strachan B. A cohort study of maternal and neonatal morbidity in relation to use of sequential instruments at operative vaginal delivery. *EJOG*. 2011;156(1):41-45. doi:10.1016/j.ejogrb.2011.01.004.

16. Allen VM, O'Connell CM, Baskett TF. Maternal and perinatal morbidity of caesarean delivery at full cervical dilatation compared with caesarean delivery in the first stage of labour. *BJOG*. 2005;112(7):986-990. doi:10.1111/j.1471-0528.2005.00615.x.

17. Crofts JF, Lenguerrand E, Bentham GL, et al. Prevention of brachial plexus injury-12 years of shoulder dystocia training: an interrupted time-series study. *BJOG*. 2015;123(1):111-118. doi:10.1111/1471-0528.13302.

18. Walsh JM, Kandamany N, Ni Shuibhne N, Power H, Murphy JF, O'Herlihy C. Neonatal brachial plexus injury: comparison of incidence and antecedents between 2 decades. *Am J Obstet Gynecol*. 2011;204(4):324.e1-.e6. doi:10.1016/j.ajog.2011.01.020.

19. Draycott TJ, Crofts JF, Ash JP, et al. Improving Neonatal Outcome Through Practical Shoulder Dystocia Training. *Obstet Gynecol*. 2008;112(1):14-20. doi:10.1097/AOG.0b013e31817bbc61.

20. Draycott T, Sibanda T, Owen L, et al. Does training in obstetric emergencies improve neonatal outcome? *BJOG*. 2006;113(2):177-182. doi:10.1111/j.1471-0528.2006.00800.x.

21. Crofts JF, Bartlett C, Ellis D, Fox R, Draycott TJ. Documentation of simulated shoulder dystocia: accurate and complete? *BJOG*. 2008;115(10):1303-1308. doi:10.1111/j.1471-0528.2008.01801.x.

22. Macleod M, Strachan B, Bahl R, et al. A prospective cohort study of maternal and neonatal morbidity in relation to use of episiotomy at operative vaginal delivery. *BJOG*. 2008;115(13):1688-1694. doi:10.1111/j.1471-0528.2008.01961.x.

23. Gauthaman N, Henry D, Ster IC, Khunda A, Doumouchtsis SK. Kielland’s forceps: does it increase the risk of anal sphincter injuries? An observational study. *Int Urogynecol J*. 2015;26(10):1525-1532. doi:10.1007/s00192-015-2717-6.

24. Wattar Al BH, Wattar BA, Gallos I, Pirie AM. Rotational vaginal delivery with Kielland’s forceps. *Curr Opin Obstet Gynecol*. 2015;27(6):438-444. doi:10.1097/GCO.0000000000000221.

25. Initiative C. CROWN Initiative. http://www.crown-initiative.org/core-outcome-sets/.

26. Andrews SE, Alston MJ, Allshouse AA, Moore GS, Metz TD. Does the number of forceps deliveries performed in residency predict use in practice? *Am J Obstet Gynecol*. 2015;213(1):93.e1-93.e4. doi:10.1016/j.ajog.2015.03.025.

27. Solt I, Jackson S, Moore T, Rotmensch S, Kim MJ. Teaching forceps: the impact of proactive faculty. *Am J Obstet Gynecol*. 2011;204(5):448.e1-448.e4. doi:10.1016/j.ajog.2010.12.056.

28. Crofts JF, Fox R, Draycott TJ, Winter C, Hunt LP, Akande VA. Retention of factual knowledge after practical training for intrapartum emergencies. *Int J Gynaecol Obstet*. 2013;123(1):81-85. doi:10.1016/j.ijgo.2013.04.015.

29. Dupuis O, Decullier E, Clerc J, et al. Does forceps training on a birth simulator allow obstetricians to improve forceps blade placement? *EJOG*. 2011;159(2):305-309. doi:10.1016/j.ejogrb.2011.09.002.

30. Siassakos D, Hasafa Z, Sibanda T, et al. Retrospective cohort study of diagnosis-delivery interval with umbilical cord prolapse: the effect of team training. *BJOG*. 2009;116(8):1089-1096. doi:10.1111/j.1471-0528.2009.02179.x.

Tables

Table 1

Demographic details of women who had a rotational operative birth by rotation technique used

		Total n=302 (%)	Manual n=208 (%)	Kielland n=104 (%)
Maternal age	<35y	253 (81.1)	170 (81.7)	83 (79.8)
	>=35y	59 (18.9)	38 (18.3)	21 (20.2)
Parity	previous pregnancy	53 (17.0)	34 (16.4)	19 (18.3)
	nulliparity	259 (83.0)	174 (83.7)	85 (81.7)
Previous natural vaginal delivery	no previous NVD	269 (86.2)	179 (86.1)	90 (86.5)
	previous NVD	43 (13.8)	29 (13.9)	14 (13.5)
Previous Caesarean section delivery	no previous CS	298 (95.5)	202 (97.1)	96 (92.3)
	previous CS	14 (4.5)	6 (2.9)	8 (7.7)
BMI	<25	183 (58.7)	116 (55.8)	67 (64.4)
	25 to 30	89 (28.5)	66 (31.7)	23 (22.1)
	≥30	38 (12.2)	25 (12.0)	13 (12.5)
	unknown	2 (0.6)	1 (0.5)	1 (1.0)
Length of gestation	<37 weeks	11 (3.5)	7 (3.4)	4 (3.9)
	>=37 weeks	284 (91.0)	185 (88.9)	99 (95.2)
	unknown	17 (5.5)	16 (7.7)	1 (1.0)
Reasons for delivery	fetal compromise	114 (36.5)	75 (36.1)	39 (37.5)
	delay	156 (50.0)	102 (49.0)	54 (51.9)
	compromise and delay	40 (12.8)	29 (13.9)	11 (10.6)
	unknown	2 (0.6)	2 (1.0)	0 (0.0)
First stage duration	<=12 hours	219 (70.2)	145 (69.7)	74 (71.2)
	> 12 hours	74 (23.7)	49 (23.6)	25 (24.0)
	unknown	19 (6.1)	14 (6.7)	5 (4.8)
Second stage duration	<=2 hours	108 (34.6)	74 (35.6)	34 (32.7)
	> 2 hours	190 (60.9)	122 (58.7)	68 (65.4)
	unknown	1 4(4.5)	12 (5.8)	2 (1.9)
Baby in-utero position	OT	169 (54.2)	125 (60.1)	44 (42.3)
	OP	122 (39.1)	65 (31.3)	57 (54.8)
	LOA/ROA	21 (6.7)	18 (8.7)	3 (2.9)
Birth weight	<4kg	255 (81.7)	169 (81.3)	86 (82.7)
	≥4kg	56 (18.0)	38 (18.3)	18 (17.3)
	unknown	1 (0.3)	1 (0.5)	0 (0.0)
Operator (years of training)	1 to 2	19 (6.1)	18 (8.7)	1 (1.0)
	3	83 (26.6)	68 (32.7)	15 (14.4)
	4 to 5	80 (25.6)	57 (27.4)	23 (22.1)
	6 to 7	90 (28.9)	48 (23.1)	42 (40.4)
	consultant	40 (12.8)	17 (8.2)	23 (22.1)
Supervision	independent	191 (61.2)	121 (58.2)	70 (67.3)
	trainee in years 6-7	68 (21.8)	60 (28.9)	8 (7.7)
	consultant	53 (17.0)	27 (13.0)	26 (25.0)

Table 2

Neonatal outcomes in relation to mode of rotational operative vaginal birth

		Total n=312(%)	**MR** n=208(%)	**RF** n=104(%)	**Adjusted RR* (95% CI)**	**p-value**
Cord gas(pH)	<7.1	41 (13.1)	23 (11.1)	18 (17.3)	1.44 (0.79 - 2.61)	0.232
	unknown	44 (14.1)	32 (15.4)	12 (11.5)		
Apgar@1mn	<=3	8 (2.6)	2 (1.0)	6 (5.8)		
	unknown	5 (1.6)	4 (1.9)	1 (1.0)		
Apgar@5mn	<7	7 (2.2)	3 (1.4)	4 (3.9)		
	unknown	4 (1.3)	3 (1.4)	1 (1.0)		
Apgar@10mn	<7	4 (1.3)	2 (1.0)	2 (1.9)		
	unknown	4 (1.3)	3 (1.4)	1 (1.0)		
Shoulder dystocia	yes	42 (13.5)	22 (10.6)	20 (19.2)	2.35 (1.23 - 4.47)	0.009
Cephalohaematoma	no	309 (99.0)	205 (98.6)	104 (100.0)		
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
Bony injury	no	309 (99.0)	205 (98.6)	104 (100.0)		
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
Facial palsy	no	308 (98.7)	204 (98.1)	104 (100.0)		
	yes	1 (0.3)	1 (0.5)	0 (0.0)		
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
Other nerve problem	no	309 (99.0)	205 (98.6)	104 (100.0)		
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
TTN	yes	6 (1.9)	4 (1.9)	2 (1.9)		
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
Jaundice	yes	11 (3.5)	9 (4.3)	2 (1.9)	1.07 (0.18 - 6.38)	0.94
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
Neonatal sepsis	yes	13 (4.2)	6 (2.9)	7 (6.7)	2.18 (0.52 - 9.17)	0.286
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
Seizure	no	309 (99.0)	205 (98.6)	104 (100.0)		
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
Other complication	yes	13 (4.2)	8 (3.9)	5 (4.8)		
	unknown	3 (1.0)	3 (1.4)	0 (0.0)		
NICU admission	admitted	26 (8.3)	17 (8.2)	9 (8.7)	1.01 (0.40 - 2.52)	0.98
	unknown	5 (1.6)	5 (2.4)	0 (0.0)		

*assessed with log-binomial regression

Table 3

Maternal outcomes in relation to mode of rotational operative vaginal birth						
		Total n=302 (%)	**MR** n=208 (%)	**RF** n=104 (%)	**Adjusted RR* (95% CI)**	**p-value**
Vaginal birth	vaginal birth	263 (84.3)	171 (82.2)	92 (88.5)	1.17 (1.04 - 1.31)	0.01
PPH	>1 litre	165 (52.9)	115 (55.3)	50 (48.1)	0.88 (0.68 - 1.13)	0.31
Anal sphincter trauma	yes	22 (7.1)	12 (5.8)	10 (9.6)	1.99 (0.90 - 4.39)	0.08
Length of hospitalisation	1 day	141 (45.2)	98 (47.1)	43 (41.4)		
	4-5 days	30 (9.6)	19 (9.1)	11 (10.6)		
	6+ days	20 (6.4)	13 (6.3)	7 (6.7)		
	unknown	4 (1.3)	3 (1.4)	1 (1.0)		
Anaemia	yes	14 (4.5)	6 (2.9)	8 (7.7)	2.52 (0.70 - 9.07)	0.15
	unknown	1 (0.3)	1 (0.5)	0 (0.0)		
Maternal Sepsis	yes	19 (6.1)	11 (5.3)	8 (7.7)	1.92 (0.78 - 4.71)	0.15
	unknown	1 (0.3)	1 (0.5)	0 (0.0)		
Other complication	yes	12 (3.9)	7 (3.4)	5 (4.8)	1.53 (0.51 - 4.57)	0.45
	unknown	1 (0.3)	1 (0.5)	0 (0.0)		

*assessed with log-binomial regression

Supplementary Table 4

Unadjusted maternal and neonatal outcomes in relation to mode of rotational operative vaginal birth

		Total n=302(%)	MR n=208(%)	RF n=104(%)	Unadjusted RR* (95% CI)
Maternal outcomes					
Vaginal birth	vaginal birth	263 (84.3)	171 (82.2)	92 (88.5)	1.08 (0.98 - 1.18)
PPH	>1 litre	165 (52.9)	115 (55.3)	50 (48.1)	0.87 (0.69 – 1.1)
Anal sphincter trauma	yes	22 (7.1)	12 (5.8)	10 (9.6)	1.67 (0.74 – 3.73)
Length of hospitalisation	1 day	141 (45.2)	98 (47.1)	43 (41.4)	1.13 (0.86 – 1.49)
	2-3 days	117 (37.5)	75 (36.1)	42 (40.4)	0.89 (0.66 – 1.19)
	4-5 days	30 (9.6)	19 (9.1)	11 (10.6)	0.86 (0.42 – 1.74)
	6+ days	20 (6.4)	13 (6.3)	7 (6.7)	0.92 (0.38 – 2.25)
	unknown	4 (1.3)	3 (1.4)	1 (1.0)	
Anaemia	yes	14 (4.5)	6 (2.9)	8 (7.7)	2.65 (0.94 – 7.46)
	unknown	1 (0.3)	1 (0.5)	0 (0.0)	
Maternal Sepsis	yes	19 (6.1)	11 (5.3)	8 (7.7)	1.45 (0.60 – 3.49)
	unknown	1 (0.3)	1 (0.5)	0 (0.0)	
Other complication	yes	12 (3.9)	7 (3.4)	5 (4.8)	1.42 (0.46 – 4.38)
	unknown	1 (0.3)	1 (0.5)	0 (0.0)	
Neonatal outcomes					
Cord gas (pH)	<7.1	41 (13.1)	23 (11.1)	18 (17.3)	1.50 (0.85 – 2.63)
	unknown	44 (14.1)	32 (15.4)	12 (11.5)	
Apgar@1mn	<=3	8 (2.6)	2 (1.0)	6 (5.8)	5.94 (1.22 – 29.00)
	unknown	5 (1.6)	4 (1.9)	1 (1.0)	
Apgar@5mn	<7	7 (2.2)	3 (1.4)	4 (3.9)	2.65 (0.6 – 11.66)
	unknown	4 (1.3)	3 (1.4)	1 (1.0)	
Apgar@10mn	<7	4 (1.3)	2 (1.0)	2 (1.9)	1.99 (0.28 – 13.97)
	unknown	4 (1.3)	3 (1.4)	1 (1.0)	
Shoulder dystocia	yes	42 (13.5)	22 (10.6)	20 (19.2)	1.82 (1.04 – 3.18)
Cephalohaematoma	no	309 (99.0)	205 (98.6)	104 (100.0)	∞
	unknown	3 (1.0)	3 (1.4)	0 (0.0)	
Facial palsy	no	308 (98.7)	204 (98.1)	104 (100.0)	∞
	yes	1 (0.3)	1 (0.5)	0 (0.0)	
	unknown	3 (1.0)	3 (1.4)	0 (0.0)	
Jaundice	yes	11 (3.5)	9 (4.3)	2 (1.9)	0.44 (0.10 – 2.00)
	unknown	3 (1.0)	3 (1.4)	0 (0.0)	
Neonatal sepsis	yes	13 (4.2)	6 (2.9)	7 (6.7)	2.3 (0.79 – 6.68)
	unknown	3 (1.0)	3 (1.4)	0 (0.0)	
Other complication	yes	13 (4.2)	8 (3.9)	5 (4.8)	1.23 (0.41 – 3.68)
	unknown	3 (1.0)	3 (1.4)	0 (0.0)	
NICU admission	admitted	26 (8.3)	17 (8.2)	9 (8.7)	1.03 (0.48 – 2.24)
	unknown	5 (1.6)	5 (2.4)	0 (0.0)	

*assessed with log-binomial regression