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SYSTEMATIC REVIEW

Maternal and neonatal complications following Kielland's rotational forceps delivery: A systematic review and meta-analysis

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Abstract

Background: There is conflicting evidence regarding the safety of Kielland's rotational forceps delivery (KRFD) in comparison with other modes of delivery for the management of persistent fetal malposition in the second stage of labour.

Objectives: To derive estimates of risks of maternal and neonatal complications following KRFD, compared with rotational ventouse delivery (RVD), non-rotational forceps delivery (NRFD) or a second-stage caesarean section (CS), from a systematic review and meta-analysis of the literature.

Search Strategy: Standard search methodology, as recommended by the *Cochrane Handbook for Systematic Reviews of Interventions*.

Selection Criteria: Case series, prospective or retrospective cohort studies and population-based studies.

Data Collection and Analysis: A meta-analysis using a random-effects model was used to derive weighted pooled estimates of maternal and neonatal complications.

Main Results: Thirteen studies were included. For postpartum haemorrhage there was no significant difference between Kielland's and ventouse delivery; the rate was lower in Kielland's delivery compared with non-rotational forceps (RR 0.79, 95% CI 0.65–0.95) and second-stage CS (RR 0.45, 95% CI 0.36–0.58). There were no differences in the rates of anal sphincter injuries or admission to neonatal intensive care. Rates of shoulder dystocia were higher with Kielland's delivery compared with ventouse delivery (RR 1.79, 95% CI 1.08–2.98), but rates of neonatal birth trauma were lower (RR 0.49, 95% CI 0.26–0.91). There were no differences seen in the rates of 5-min APGAR score < 7 between Kielland's delivery and other instrumental births, but they were lower when compared with second-stage CS (RR 0.47, 95% CI 0.23–0.97).

Conclusions: Kielland's rotational forceps delivery is a safe option for the management of fetal malposition in the second stage of labour.

KEYWORDS
birth trauma, fetal malposition, Kielland's forceps, postpartum haemorrhage, rotational forceps delivery

1 | INTRODUCTION

Malposition in labour is a term used to describe a fetus in a cephalic presentation with the fetal occiput in a transverse (OT) or posterior (OP) position, in relation to the maternal spine.[1] If the position remains OT or OP at the end of the active phase of the second stage of labour, persistent fetal malposition (PFM) is diagnosed. There are essentially four management options for PFM: Kielland's rotational forceps delivery (KFRD); rotational

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ventouse delivery (RVD); non-rotational instrumental delivery, with or without manual rotation; or second-stage caesarean section (CS). There are no randomised controlled trials (RCTs) comparing the risks of maternal and neonatal complications between KRFD with any of the above-mentioned management options, and the evidence for clinical practice is based on small case series, case–control and retrospective cohort studies.[2–9] There is significant disparity and conflicting evidence in reference to the use KRFD in comparison with other management options for PFM, with reports of increased,[8,9] similar,[2,3,5] and lower[4,6,7] rates of maternal and neonatal complications. The implication of such contradictory information is that there is significant variation in clinical practice, with many units abandoning the use of KRFD because of a perceived increase in the rate of complications; this in turn negatively impacts the training of doctors and affects the maintenance of skills for practicing obstetricians.

The objective of this study was to undertake a systematic review and meta-analysis to derive accurate estimates of the risks of maternal and neonatal complications following KRFD, compared with RVD, NRFD and second-stage CS.

2 | METHODS

2.1 | Data sources and search strategy

This systematic review and meta-analysis was undertaken based on a study protocol designed apriori and recommended for systematic reviews and meta-analyses.[10] The study protocol of the systematic review was registered in advance with PROSPERO (registration no. CRD42020190343). An electronic search of MEDLINE, EMBASE and The Cochrane Library was carried out on 30 October 2021, using combinations of the relevant medical subject heading (MeSH) terms, keywords and word variants for 'maternal complications', 'neonatal complications', 'Kielland's forceps' OR 'Keilland's forceps' OR 'Kjelland's forceps', 'rotational delivery', 'operative forceps delivery' OR 'instrumental forceps delivery', 'mid-cavity forceps' OR 'high-cavity forceps', 'deep transverse arrest' OR 'malposition' (Appendix S1). The search was repeated on 30 June 2022 to review whether any recent studies were published in the time since the original search was carried out. The citations retrieved following this search strategy were examined for relevance to this systematic review based on the reporting of maternal and neonatal complications, study design, event rates for complications, sample size of the studies and the study period. The search and selection criteria were restricted to studies published in the English language. We complemented the searches by perusing the references of retrieved articles.

2.2 | Eligibility and selection criteria for studies

We included case series, prospective or retrospective cohort studies and population-based studies reporting maternal and neonatal complications in singleton pregnancies delivered by KRFD, compared with deliveries by RVD, NRFD or second-stage CS. We only included studies that were published after the year 2000 to reflect current obstetric and neonatal clinical practice. The citations were examined by two reviewers (TG and RK) to produce a list of relevant studies to be potentially included in the systematic review. We excluded duplicate studies, those that did not fit the selection criteria after review of the title and abstract, single case reports, letters to the editor, review articles without any original data, conference abstracts and studies on multiple pregnancies. These two authors independently assessed all the potential studies identified from the search strategy for inclusion and extracted data using a pre-specified template. The reference lists of relevant articles and reviews were reviewed for additional studies and any inconsistencies were discussed with a third reviewer (RA), to reach a consensus.

2.3 | Data extraction and synthesis

For each study included in the systematic review, information about the following was extracted: authors; year of enrolment for cases and, if applicable, for controls; study design; whether the study was single- or multicentre; whether the study included deliveries by KFRD, RV or NRFD; and rates of any subsequent maternal and neonatal complications.

The primary outcome measure was assessing maternal and neonatal outcomes following KRFD. Maternal adverse outcomes included postpartum haemorrhage (PPH) and obstetric anal sphincter injury (OASIS), whereas neonatal adverse outcomes included admission to neonatal intensive care unit (NICU), 5-min Apgar scores < 7, hypoxic ischaemic encephalopathy (HIE), shoulder dystocia and neonatal birth trauma. The data for these outcomes were entered in contingency tables for KFRD, RVD, NRFD and second-stage CS. Haldane correction was used to account for small event rates to allow for the estimation of variance and pooled effects.

2.4 | Quality assessment

The methodological quality of studies included in the review was assessed using the Newcastle–Ottawa scale (NOS).[11] The assessment of the domains in the scale was performed based on a standardised checklist with the number and combination of stars expressing the overall quality of the included studies in an Agency for Healthcare Research and Quality (AHRQ)-compliant way (good, fair or poor) (Appendix S2). The quality of this systematic review and meta-analysis was validated using the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) checklist (Appendix S3).[12]

2.5 | Meta-analysis and estimation of pooled statistics

A meta-analysis of the extracted data was carried out with the following steps: the data were extracted for each study to document the study design, the sample size in each study

group (KRFD, RVD, NRFD or second-stage CS) and the event rates for PPH, OASIS, admission to NICU, neonatal birth trauma, shoulder dystocia and 5-min Apgar < 7. Data were entered in contingency tables and rates of maternal and neonatal complications with 95% confidence intervals (95% CIs) were estimated for each type of delivery in each study, weighted by its sample size. We estimated summary statistics and measures of effect size reflected in relative risk (RR) with 95% CIs for each study, and these individual study statistics were then combined to obtain a pooled summary estimate for each of the adverse outcomes, which was calculated as a weighted average of the individual study estimates. The pooled summary statistics were estimated using both fixed- and random-effects models. We chose the random-effects model estimates as they assess not only the variation within studies but also between various studies, and therefore provided a conservative estimate of pooled statistics with wider 95% CIs.[13] Forrest plots for each maternal and neonatal complication were constructed, and the final pooled estimates were estimated using data from the random-effects model. The statistical software packages StatsDirect 2.7.9 (StatsDirect Ltd) and MedCalc Statistical Software 16.4.3 (MedCalc Software Ltd) were used for data analysis.

2.6 | Assessment of heterogeneity and bias

The heterogeneity between studies was estimated using Cochrane's heterogeneity statistic *Q*. Inconsistency between study results was assessed using the I^2 statistic, which is calculated as $I^2 = 100\% \times (Q - df)/Q$, where *Q* is the Cochrane's heterogeneity statistic and *df* is the number of degrees of freedom. The I^2 statistic described the percentage of variation across studies caused by heterogeneity rather than by chance and was particularly useful as it did not depend on the number of studies in the meta-analysis.

3 | RESULTS

3.1 | Data search results

The electronic search of the databases produced 3778 potential citations. From these, 2133 citations did not meet the inclusion criteria for the study, as they were published before the year 2000 (1882) or were non-English citations (251). A further 102 citations were excluded as they were duplicates. A total of 1466 citations were excluded after reviewing the title (1374) and abstract (92). Seventy-seven articles were retrieved in full text for detailed assessment and a further 64 studies that did not meet the selection criteria were excluded; thus, a total of 13 studies were included in the systematic review and meta-analysis.[2,4–7,9,14–20] The study selection process is shown in Figure 1 and the search strategy is outlined in Appendix S1.

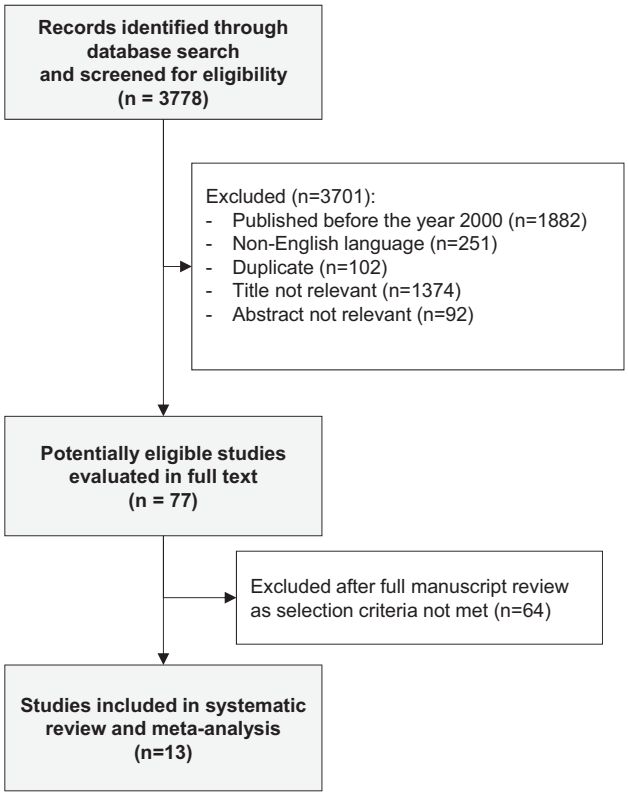

FIGURE 1 Flowchart demonstrating the selection of studies included in the systematic review and meta-analysis.

3.2 | Characteristics of included studies

The 13 studies included in the systematic review describe pregnancy outcomes following KRFD, with 11 studies reporting on both maternal and neonatal outcomes,[2,4–7,9,14,16,17,19,20] and with two studies reporting on maternal outcomes only.[15,18] Of these included studies, nine were retrospective cohort studies,[4,6,7,9,14–18] two were prospective cohort studies,[5,20] one was a matched case–control study,[2] and one was a case series.[19] With regards to the reporting of maternal adverse outcomes of PPH, there were variations in the definition of PPH between studies: two studies used a definition of estimated blood loss (EBL) > 500 ml;[4,5] three studies used EBL > 1 litre;[6,16,17] and one study used a cut-off of 1.5 litres.[20] There was uniformity in the definition of OASIS, with all studies including either third- or fourth-degree perineal damage as the definition of OASIS. There was no variation in the reported measures of neonatal outcomes, such as admission to NICU, shoulder dystocia and neonatal birth trauma. Neonatal birth trauma was defined when one of the following were present: cephalhematoma; retinal haemorrhage; skin or scalp lacerations; facial injuries (haematoma or nerve injury); fractures of the clavicle or humerus; or obstetric brachial plexus injury, based on clinical examination by a senior neonatal doctor. With regards to 5-min APGAR score, all the studies used a cut-off score of <7, except one study that used a cut-off score of <5.[20]

3.3 | Assessment of quality and heterogeneity of studies

The methodological quality of the studies included in this systematic review was assessed using the NOS. The rating of the studies, based on the selection and comparability of the study groups and the ascertainment of the outcome of interest, is shown in Appendix S2. The PRISMA guidance was followed for reporting this meta-analysis (Appendix S3). The MOOSE (Meta-analysis Of Observational Studies in Epidemiology) checklist was used for the reporting of meta-analyses of observational studies (Appendix S4).

3.4 | Maternal adverse outcomes

In pregnancies with KRFD, there was no significant difference in the rate of PPH compared with RVD (RR 0.87, 95% CI 0.68–1.11; $p = 0.257$), whereas the rate of PPH was significantly lower in pregnancies with KRFD compared with NRFD (RR 0.79, 95% CI 0.65–0.95, $p = 0.012$) or with second-stage CS (RR 0.45, 95% CI 0.36–0.58, $p < 0.001$) (Figure 2; Table S1). With regards to risk of perineal damage, there was no significant difference in the rate of OASIS in pregnancies with KRFD compared with RVD (RR 1.09, 95% CI 0.70–1.71, $p = 0.705$) or with NRFD (RR 0.81, 95% CI 0.60–1.09, $p = 0.157$) (Figure 3; Table S2).

3.5 | Neonatal adverse outcomes

There was no significant difference in the rate of admission to NICU in pregnancies with KRFD compared with RVD (RR 1.16, 95% CI 0.76–1.78, $p = 0.488$), NRFD (RR 0.77, 95% CI 0.54–1.10, $p = 0.151$) and second-stage CS (RR 0.81, 95% CI 0.59–1.11, $p = 0.188$) (Figure 4; Table S3). In pregnancies with KRFD, there was a higher risk of shoulder dystocia (RR 1.79, 95% CI 1.08–2.98, $p = 0.024$) compared with RVD, but there was no significant difference in pregnancies with KRFD compared with NRFD (RR 1.30, 95% CI 0.86–1.95, $p = 0.210$) (Figure 5; Table S4). There was a significantly lower rate of neonatal birth trauma in pregnancies with KRFD,

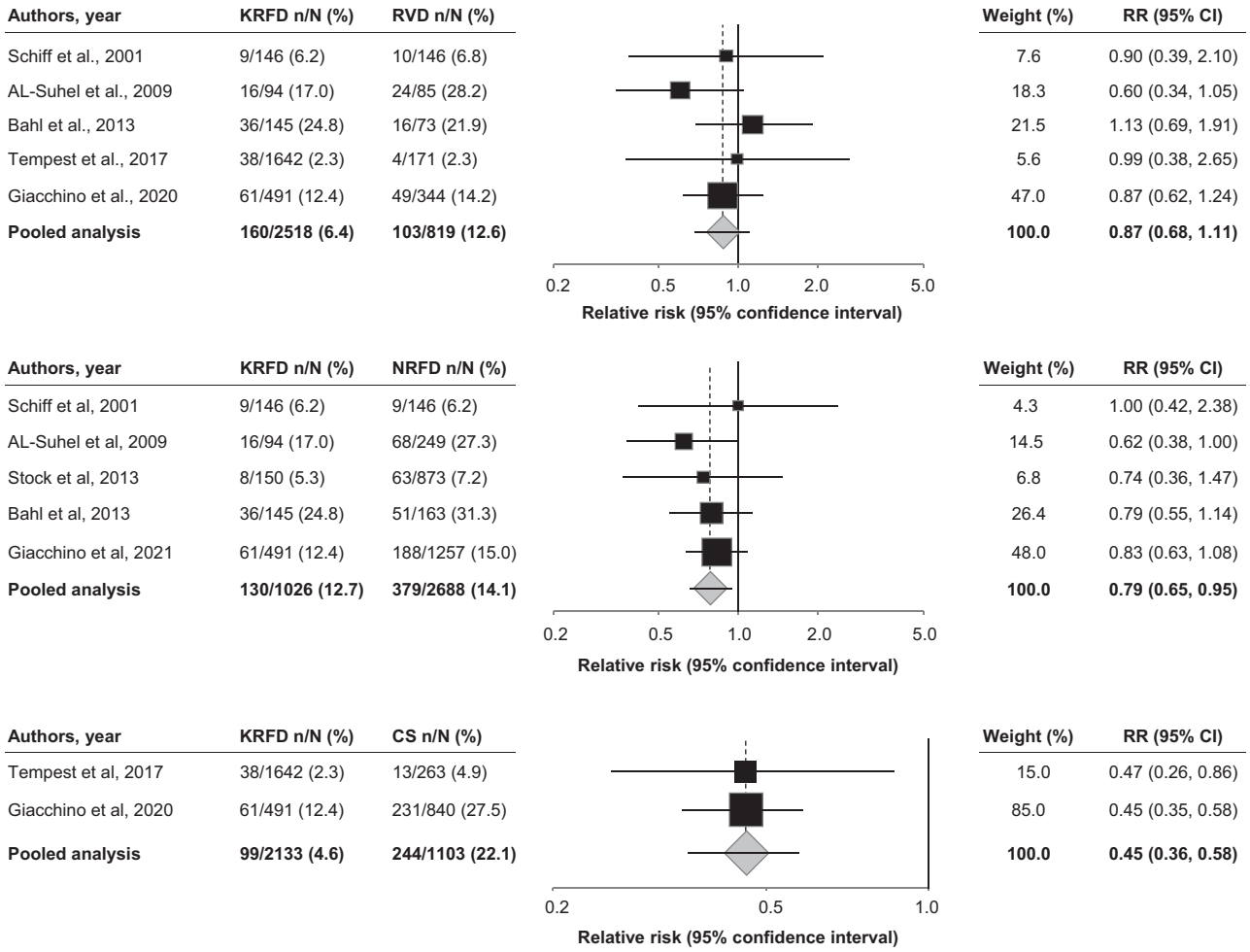

FIGURE 2 Forest plot demonstrating summary statistics for risk of postpartum haemorrhage (PPH) in pregnancies delivering by Kielland's rotational forceps delivery (KRFD) compared with pregnancies delivering by rotational ventouse delivery (RVD), non-rotational forceps delivery (NRFD) and second-stage caesarean section (CS).

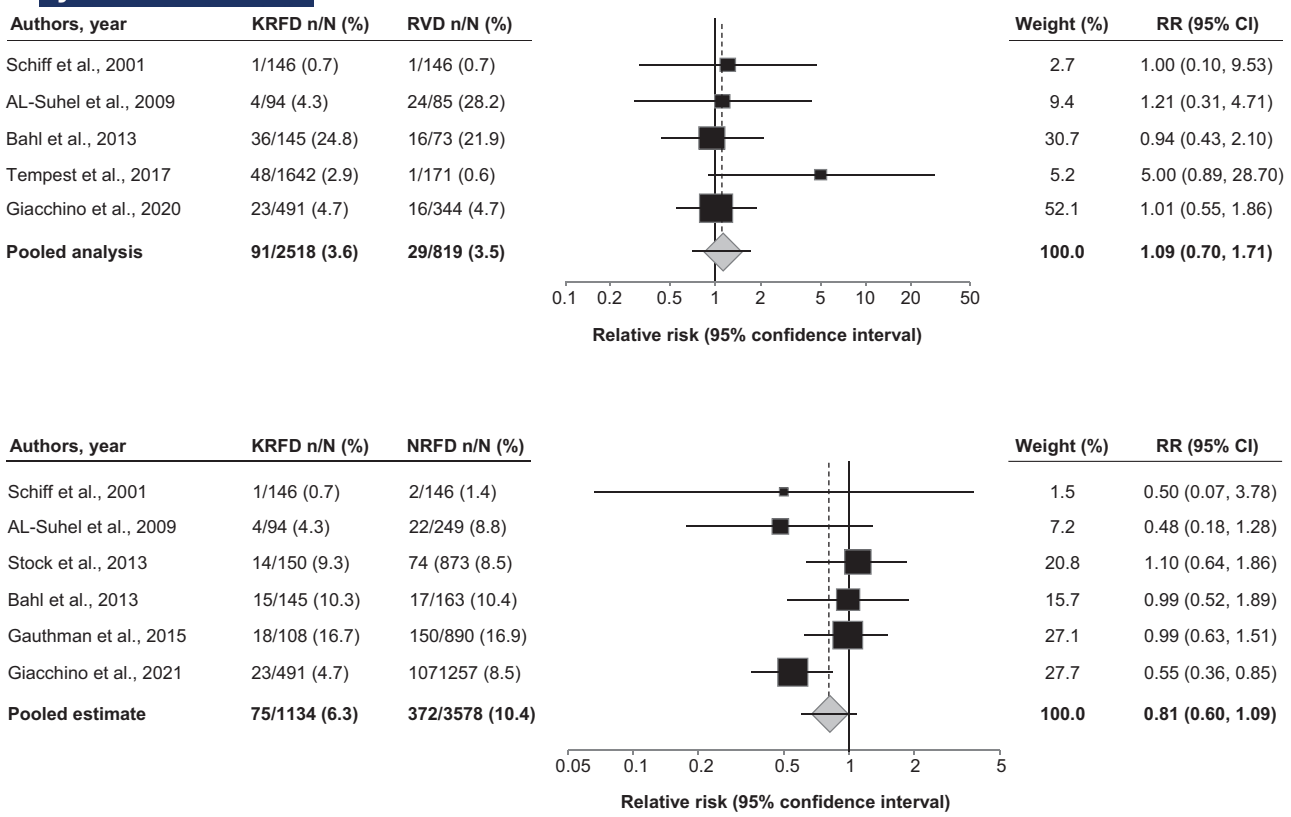

FIGURE 3 Forest plot demonstrating summary statistics for risk of obstetric anal sphincter injury (OASIS) in pregnancies delivering by Kielland's rotational forceps delivery (KRFD) compared with pregnancies delivering by rotational ventouse delivery (RVD) and non-rotational forceps delivery (NRFD).

compared with RVD (RR 0.49, 95% CI 0.26–0.91, $p = 0.024$), whereas there was no significant difference in pregnancies with KRFD compared with NRFD (RR 0.71, 95% CI 0.41–1.22, $p = 0.217$) (Figure 6; Table S5). There was no significant difference in the rate of 5-min APGAR score < 7 in pregnancies with KRFD, compared with RVD (RR 0.72, 95% CI 0.37–1.42, $p = 0.345$) or NRFD (RR 0.75, 95% CI 0.40–1.42, $p = 0.380$), but compared with second-stage CS, the risk in pregnancies with KRFD was significantly lower (RR 0.47, 95% CI 0.23–0.97, $p = 0.040$) (Figure 7; Table S6). With regards to HIE, there was only one study that reported the rate of HIE in pregnancies with KRFD compared with RVD. In pregnancies with KRFD, there were no cases of HIE amongst a total of 491 deliveries, whereas in 344 pregnancies with RVD there were three cases of HIE, with a rate of 0.9% (3/344, RR 0.12, 95% CI 0.01–2.32). There were two studies that reported the rates of HIE in pregnancies with KRFD compared with NRFD. In pregnancies with KRFD, the HIE rate was 0.2% (1/641) compared with 0.1% (3/2130) in pregnancies with NRFD, with no significant difference in the HIE rate (RR 2.21, 95% CI 0.31–15.66, $p = 0.426$). There was one study reporting the rate of HIE in pregnancies with KRFD compared with second-stage CS, with no cases of HIE amongst a total of 491 KRFDs, whereas in pregnancies with CS there were three cases of HIE, with a rate of 0.4% (3/840, RR 0.06, 95% CI 0.01–2.37).

4 | DISCUSSION

4.1 | Main findings

The findings of this systematic review and meta-analysis demonstrate that KRFD is a safe management option in pregnancies with persistent fetal malposition in the second stage of labour, when compared with other management options such as RVD, NRFD and second-stage CS. The rate of PPH in pregnancies with KRFD was significantly lower compared with NRFD and second-stage CS. KRFD was associated with a significantly increased rate of shoulder dystocia compared with RVD, but without any increase in neonatal adverse outcomes. KRFD was associated with significantly lower rates of neonatal birth trauma and 5-min APGAR score < 7, when compared with RVD and second-stage CS, respectively. There was no significant different in the rates of OASIS and admission to NICU in pregnancies with KRFD, compared with RVD, NRFD and second-stage CS.

4.2 | Strengths and limitations

The strength of our study is that it summarises the results of contemporary studies that compare different methods of management of fetal malposition in the second stage of labour

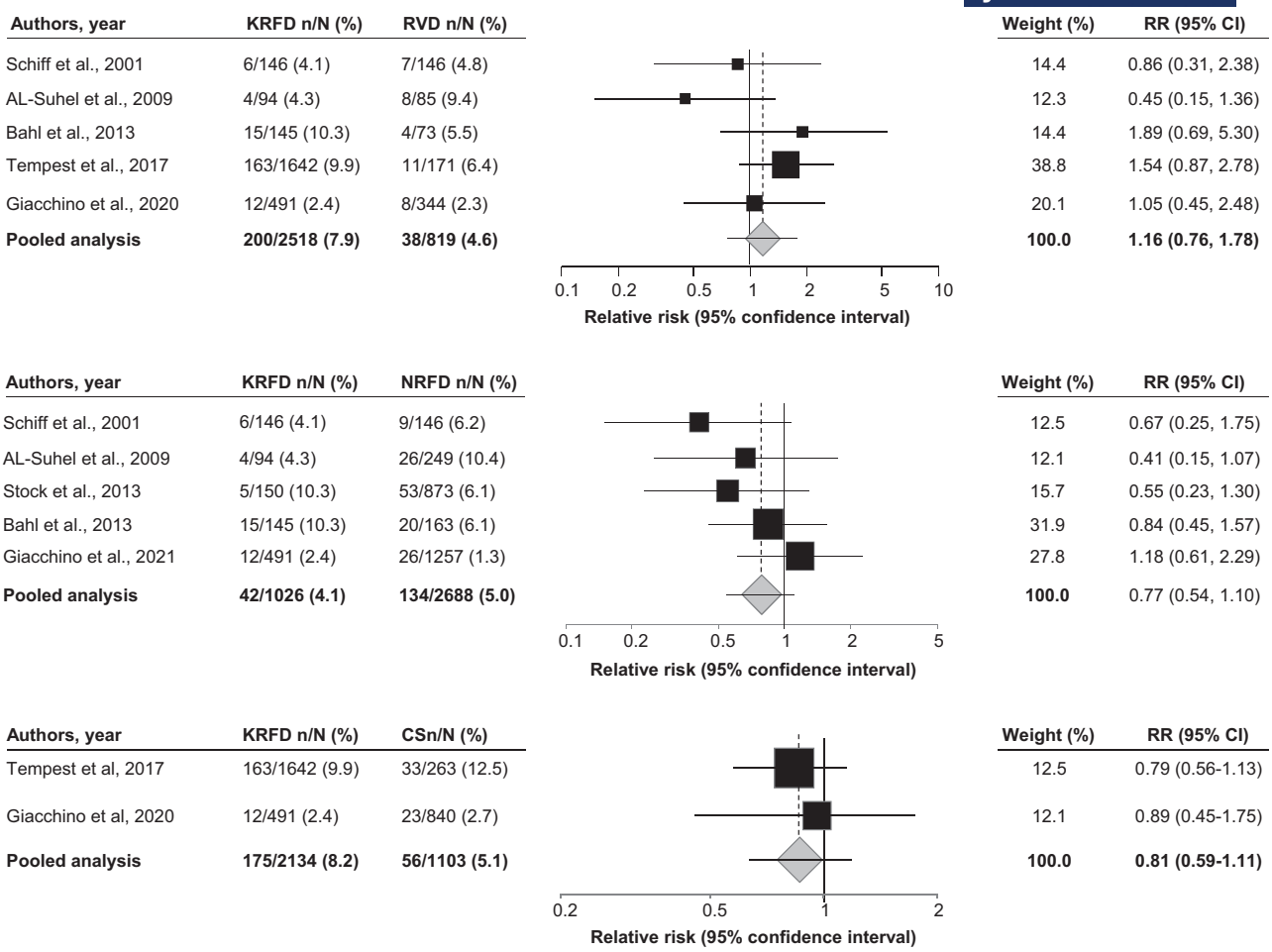

FIGURE 4 Forest plot demonstrating summary statistics for risk of admission to neonatal intensive care unit (NICU) in pregnancies delivering by Kielland's rotational forceps delivery (KRFD) compared with pregnancies delivering by rotational ventouse delivery (RVD), non-rotational forceps delivery (NRFD) and second-stage caesarean section (CS).

and provides measures of effect size for common obstetric and neonatal adverse outcomes for these different management options. Our systematic review and meta-analysis was registered in advance on PROSPERO, an international register of systematic reviews. We used a systematic search strategy using standard and well-defined search criteria, and we undertook an assessment of the quality of the studies using the NOS scale and validated the quality of our review using PRISMA. The limitation of our study is related to the heterogeneity between studies with regards to differences in sample size, definitions of adverse outcomes and variation in clinical practices in individual centres, which are all standard limitations of any systematic review or meta-analysis. However, we adopted a robust methodology to overcome these biases, such as the use of strict selection criteria for inclusion in the study, the use of a random-effects model to minimise the impact of heterogeneity between studies by considering between-study variance, weighting the studies based on sample size and providing estimates of summary statistics with wider estimates of 95% CIs, which are more clinically applicable, with the caveat that not all aspects of heterogeneity between studies can be addressed. As there are no published randomised studies comparing KRFD with other options for the management of fetal malposition, we used the data published from non-randomised cohort studies, but we acknowledge that despite the use of a stringent methodology for our systematic review, we could not compensate for biases fundamental to non-randomised studies. Maternal and pregnancy characteristics such as the use of maternal age, body mass index, ethnicity, epidural analgesia, length of first and second stage of labour or fetal position were not consistently reported in all studies, and therefore were not included in the analysis or assessment of heterogeneity. There was no consistent reporting in studies of the initial or sequential use of instruments used to achieve delivery; therefore, the assessment of complications and study analysis was based on the instrument reported in the included studies. A limitation of our study also includes a lack of comparison with manual rotation as a management option.

4.3 | Comparison with other studies

The findings of our study are comparable with the findings of a previous systematic review conducted by Al-Wattar et al., in which the authors compared the rates of complications

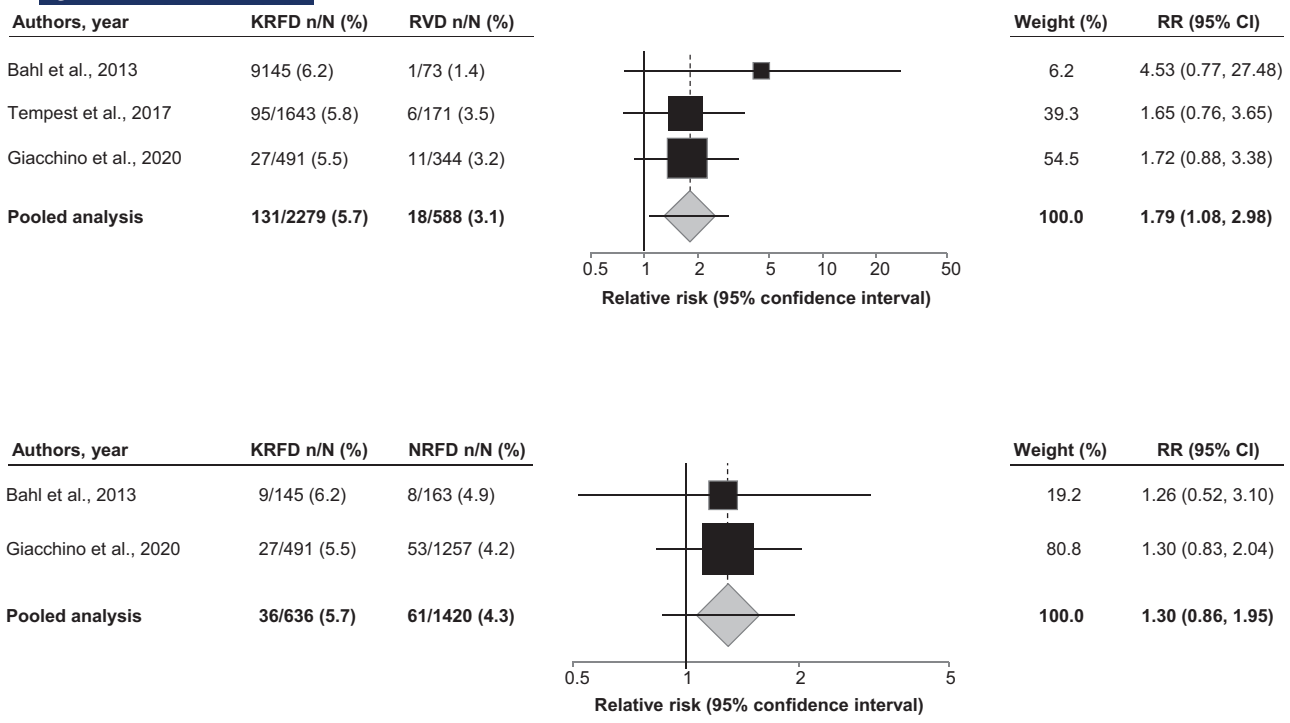

FIGURE 5 Forest plot demonstrating summary statistics for risk of shoulder dystocia in pregnancies delivering by Kielland's rotational forceps delivery (KRFD), compared with pregnancies delivering by rotational ventouse delivery (RVD) and non-rotational forceps delivery (NRFD).

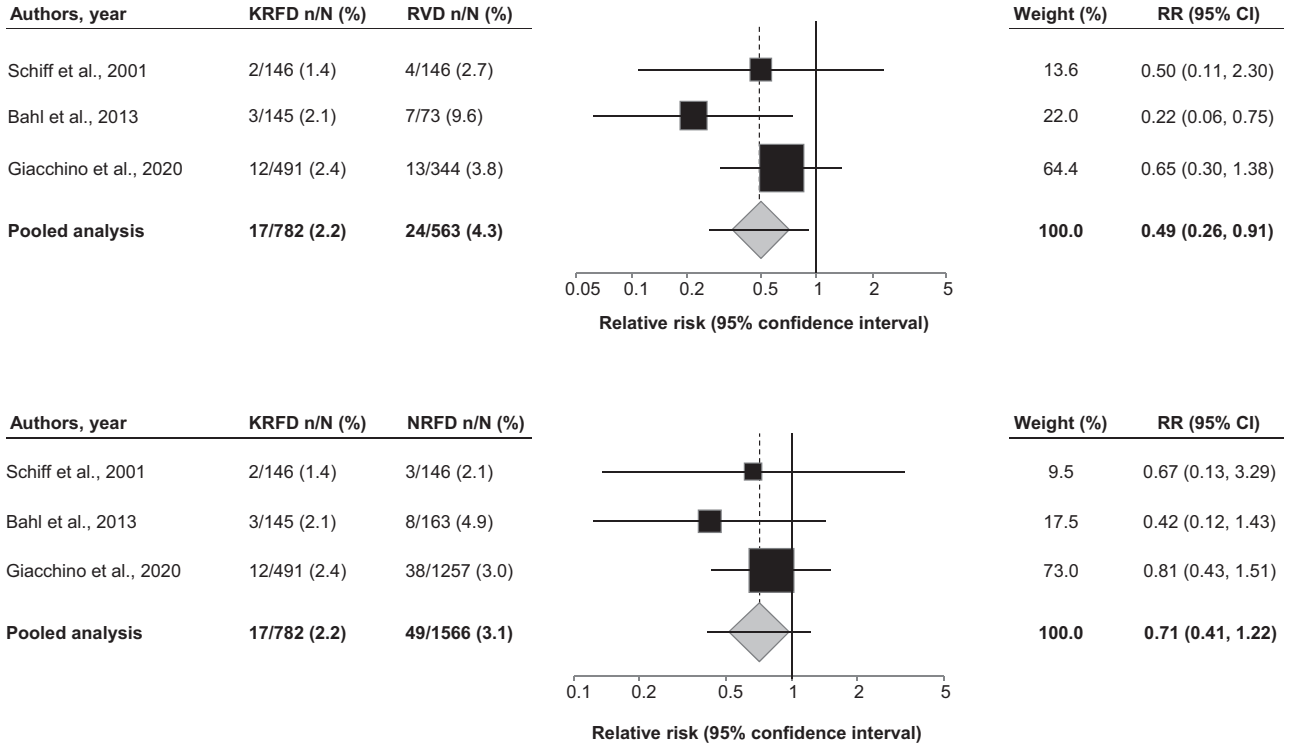

FIGURE 6 Forest plot demonstrating summary statistics for risk of neonatal birth trauma in pregnancies delivering by Kielland's rotational forceps delivery (KRFD) compared with pregnancies delivering by rotational ventouse delivery (RVD) and non-rotational forceps delivery (NRFD).

in pregnancies with KRFD to pregnancies that delivered by RVD.[21] They reported that KRFD was associated with a lower rate of neonatal birth trauma in comparison with RVD (RR 0.62, 95% CI 0.46–0.85, $p = 0.003$), which is similar to the results of our study, which demonstrated a 50% lower chance of neonatal birth trauma in pregnancies with KRFD, compared with RVD (RR 0.49, 95% CI 0.26–0.91, $p = 0.024$). Al-Watter et al. also reported no statistically significant difference in the

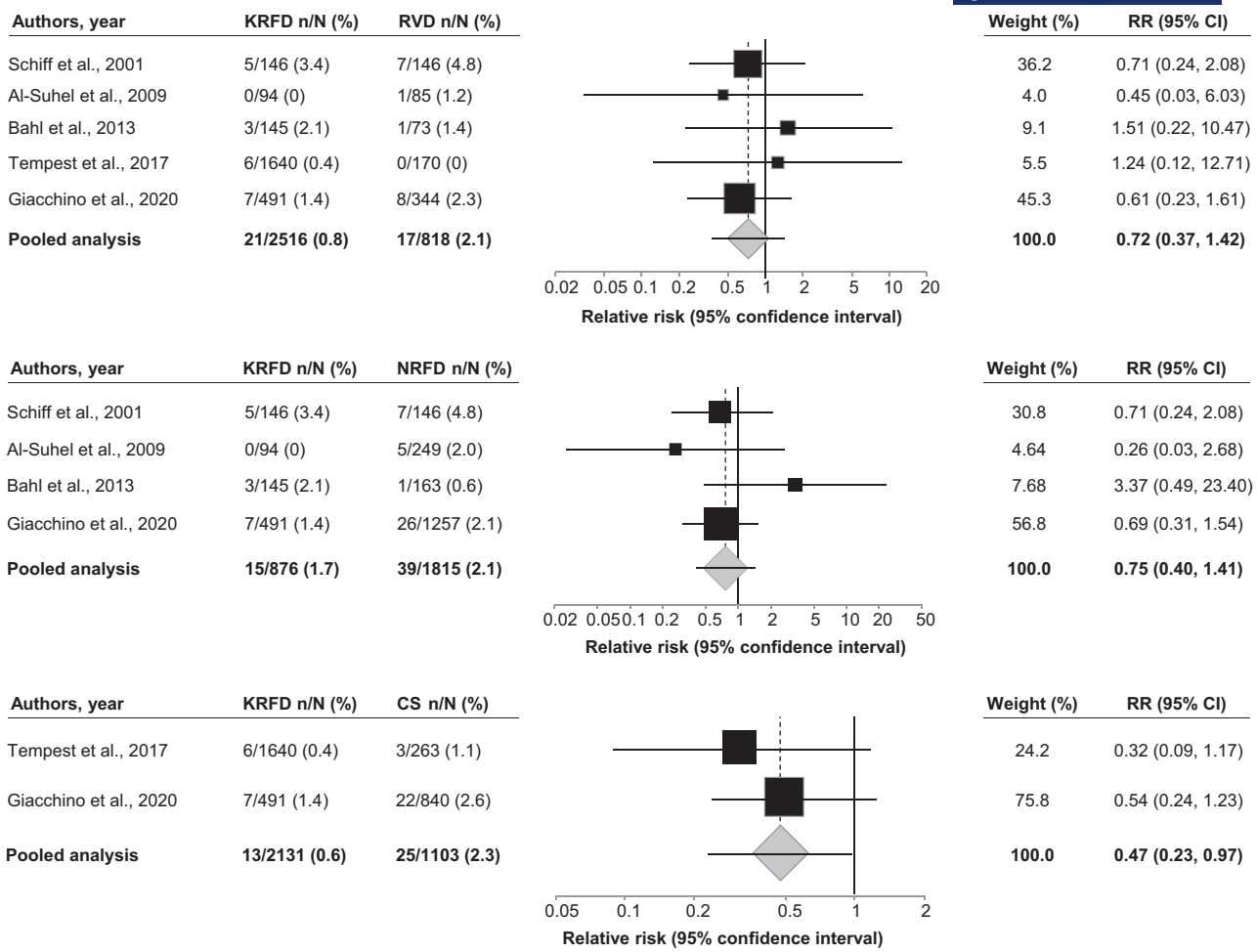

FIGURE 7 Forest plot demonstrating summary statistics for risk of 5-minute APGAR score < 7 in pregnancies delivering by Kiellands rotational forceps delivery (KRFD) compared to those delivering by rotational ventouse delivery (RVD), non-rotational forceps delivery (NRFD) and second stage caesarean section (CS).

incidence of OASIS, PPH, admission to NICU and shoulder dystocia between KRFD and RVD; our results are consistent with these findings, except for an increased risk of shoulder dystocia with KRFD, compared with RVD. However, this did not appear to be associated with any increase in the risk of neonatal complications. The advantage of our study over the previous systematic review is that our study not only compared KRFD with RVD but also compared KRFD with NRFD and with second-stage CS, which are common strategies used for the management of fetal malposition. Additionally, to ensure that our results are relevant to current obstetric and neonatal practice, we only included studies published after the year 2000, to reflect contemporary clinical practice.

4.4 | Conclusions and implications for clinical practice

Kielland's rotational forceps delivery (KRFD) is a safe management option for persistent fetal malposition in the second stage of labour, and is associated with a lower rate of PPH compared with NRFD and second-stage CS, a lower rate of neonatal birth trauma compared with RVD and a lower rate of 5-min APGAR score < 7 compared with second-stage CS. The decline in the use of rotational forceps deliveries is primarily linked to the reported association with neonatal complications based on small case studies published decades ago.[8,22] It is important for senior obstetricians and trainees to be aware of the safety of KRFD as a management option when faced with persistent fetal malposition in the second stage of labour. The importance of training in rotational deliveries needs to be emphasised through regular simulation training as well as through direct supervision by experienced operators. The results of this systematic review and meta-analysis, based on the evidence available from observational cohort studies, provide evidence that rotational delivery with Kielland's forceps is clinically safe in the management of persistent fetal malposition.

AUTHOR CONTRIBUTIONS

TG and RA contributed to the conception, planning, execution, analysis, writing and editing the final article. TG and RK contributed to the literature search, study selection, data extraction and assessment of study quality. HA reviewed the article critically for important intellectual content.

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CONFLICT OF INTEREST STATEMENT

None declared. Completed disclosure of interests form available to view online as supporting information.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS APPROVAL

This study did not require ethical approval.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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