


CLINICAL ARTICLE**Obstetrics**

Which type of forceps is better for nonrotational operative births? A simulation study comparing Thierry spatulas and Simpson-Braun and Kielland forceps

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Abstract

Objective: Obstetric forceps play an important role in safe childbirth, yet there is a lack of distinction between various forceps types in clinical practice. This study aimed to evaluate and compare perineal pressure and forces on the baby during non-rotational forceps-assisted births using Simpson-Braun forceps, Kielland forceps, and Thierry spatulas on a simulation model.

Methods: This experimental study involved six obstetricians conducting 108 forceps-assisted births on a simulation model. Instruments were assessed for their impact on perineal pressure, traction force, and operator-assessed difficulty.

Results: Thierry's spatulas exerted the lowest force on the baby, while Kielland forceps exhibited the lowest perineal pressure, though not statistically significant. An experienced obstetrician demonstrated less perineal pressure with Simpson forceps. Notably, no significant differences in difficulty were observed between instruments.

Conclusion: This study highlights distinctions in forceps performance, with Thierry spatulas applying the least force on the fetal head, while an experienced obstetrician fared better with Simpson forceps in terms of perineal pressure. Kielland forceps remain a viable alternative for nonrotational forceps births, showing comparable outcomes.

KEYWORDS

assisted birth, birth, birth injuries, obstetrical forceps, operative birth, perineum, simulation training

1 | INTRODUCTION

Obstetric forceps are specialized medical instruments designed to assist in the safe delivery of a baby during childbirth. They have played a crucial role in obstetric practice for centuries.¹ There are several distinct types of obstetric forceps, each tailored

to specific clinical scenarios and anatomical considerations. Understanding the variations in forceps designs and their appropriate applications was fundamental for healthcare professionals involved in obstetric care. However, currently, forceps are often referred to in general terms without distinguishing between the different types.^{2,3}

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Most forceps are distinguished based on their curves (pelvic and cephalic), their articulation or lock, and their handle.³ Furthermore, there are differences based on the shank, the presence or absence of an axis traction device, and the length of the instrument.⁴ In Spain, three main types of forceps are primarily used: Simpson-Braun forceps, Kielland forceps, and Thierry spatulas.⁵ Despite their marked differences in design and mechanism of action, all three types are frequently employed in nonrotational forceps births. Indeed, the clinical guidelines of the main scientific societies do not distinguish between the different types of forceps in their recommendations for nonrotational forceps, leaving the obstetrician to decide which one to use based on their training.⁵⁻⁸

In the use of obstetric forceps, there are two primary concerns: the risk of harming the mother and the risk of harming the baby.^{1,3} Concerning the mother, the greatest worries arise from the risk of perineal injuries. Obstetric forceps are associated with a higher risk of severe perineal tears.³ As for the baby, although they are considered very safe instruments, there is a risk of traumatic injuries, especially in the case of improper technique.^{3,4}

Simulation is the ideal study method for evaluating various instruments in obstetrics. It enables the examination of different types of obstetric forceps and their applications without posing any risk to women or infants.⁹ Furthermore, it allows for multiple repetitions under consistent anthropometric conditions.

The aim of this study is to assess and compare the pressure and forces exerted on the perineum and the baby during nonrotational forceps-assisted births, utilizing various instruments. This comparison was conducted using Simpson-Braun forceps, Kielland forceps, and Thierry spatulas on a simulation model.

2 | MATERIALS AND METHODS

This was a simulation-based, experimental, prospective, non-blinded, randomized, three-armed study. The ethics committee of Hospital Universitario La Paz granted an exemption from approval in July 2023, as human patients were not involved. Given the absence of human participants, informed consent was unnecessary. The institutional board approved the investigation (TFG-NIA 379930).

This experimental study involved six obstetricians performing 108 forceps-assisted births on a simulation model. The simulation used a PROMPT Flex—Advanced Birthing Simulator (Limbs & Things LTD), specifically designed to facilitate the monitoring of applied force on the baby. In addition, a Koala pressure catheter (Laborie) was employed and positioned in the perineum of the simulator, located between the vagina and the anus (Figure 1).

The participating obstetricians were required to have clinical experience using Simpson-Braun forceps, Kielland forceps, and Thierry spatulas. Their years of experience and their preference for one instrument over another were recorded. Additionally, they performed a nonrotational operative birth with each instrument on the simulator as a familiarization exercise before the study.



FIGURE 1 Location of the pressure catheter (IUPC).

The three instruments used were Simpson-Braun forceps, Kielland forceps, and Thierry spatulas. Simpson forceps were originally designed by the Scottish obstetrician Sir James Young Simpson. Simpson-Braun forceps are a variation of the Simpson forceps and are characterized by their elongated cephalic curve, pelvic curve, English lock mechanism, and grooved handle. They are available in two sizes: 33 cm and 36 cm. In our study, we used the 36-cm Simpson-Braun forceps (Figure 2). Kielland forceps were designed by the Norwegian obstetrician Christian Caspar Gabriel Kielland. Kielland forceps are 41-cm long and are characterized by their almost nonexistent pelvic curve, along with a sliding lock mechanism (Figure 3). Finally, the Thierry spatulas were named after the French obstetrician Pierre Emile Adolphe Thierry. Thierry spatulas consist of two independent symmetrical blades (nonarticulated forceps). Each spatula is composed of a handle, a shaft, and properly a blade. Each spatula measures 39.5 cm and practically lacks pelvic curvature (Figure 4).

Regarding the technique used with each instrument, the insertion of the blades with all three instruments was performed following the Madame LaChapelle maneuver. Subsequently, traction was applied using the Pajot-Saxtorph maneuver with the Simpson-Braun and Kielland forceps¹⁰ (Videos S1 and S2). With Thierry spatulas, each blade is held with each hand, and the fetal head is guided through the birth canal by propelling it along the curve of Carus¹¹ (Video S3). Finally, with all three instruments, the blades of the forceps were extracted before the complete birth of the head.¹²

The obstetricians were randomly allocated to use the different instruments in various sequences. Each participant had to perform a total of 18 nonrotational forceps-assisted births, with six using each instrument. The fetal head station was +2 for all operative births. The same baby and pelvis mannequin were used in all simulations.

The data collected for each nonrotational forceps-assisted birth included four variables: the highest traction force applied to the infant, the maximum pressure recorded on the perineum, the duration of traction, and the obstetrician's subjective assessment of difficulty (categorized using a five-point Likert scale).



FIGURE 2 Simpson-Braun forceps.



FIGURE 3 Kielland forceps.

The sample size (number of nonrotational forceps simulations) was determined based on data from a pilot study that exclusively utilized Kielland forceps. The sample size was calculated to demonstrate a difference of at least 25N in the force applied to the infant and a minimum of 25mm Hg in pressure on the perineum. For the force applied to the infant, considering a standard deviation of 29.05, an α level of 0.01, and a power (1 – beta) of 80%, a sample size of 33 nonrotational forceps simulations per group was required. Regarding pressure on the perineum, with a standard deviation of

17.40, an α level of 0.01, and a power (1 – beta) of 80%, a sample size of 11 nonrotational forceps simulations in each group was deemed necessary. An α level of 0.01 was set to account for multiple comparisons. It was determined that 36 nonrotational forceps simulations would be performed with each instrument, resulting in a total of 108 forceps-assisted simulations.

The distribution of the variables was assessed using the Shapiro–Wilk test and through visual examination of histograms. Numerical variables are presented as median (interquartile range), while



FIGURE 4 Thierry spatulas.

TABLE 1 Comparison between the different forceps.

| | Simpson-Braun | Kielland | Thierry | P value |
|----------------------------------|---------------------|---------------------|--------------------|---------|
| | (n=36) | (n=36) | (n=36) | |
| Force on the baby (N) | 39.5 (19.75; 50.75) | 34.5 (18.0; 46.5) | 16.5 (10.0; 24.0) | <0.001 |
| Pressure on the perineum (mm Hg) | 72.0 (51.0; 85.75) | 63.5 (48.25; 75.75) | 71.5 (63.25; 83.0) | 0.096 |
| Traction time (s) | 22.5 (15.0; 28.0) | 21.0 (17.0;27.0) | 19.0 (16.0; 28.0) | 0.925 |
| Any difficulties | 8 (22.2%) | 6 (16.7%) | 10 (27.8%) | 0.526 |

Note: Data are presented as median (interquartile range) and absolute and relative frequencies for qualitative variables.

qualitative variables are expressed as proportions (absolute and relative frequencies). Group comparisons were conducted using Mann–Whitney *U*, Kruskal–Wallis *H*, two-tailed χ^2 , or two-tailed Fisher exact tests as appropriate. To assess the influence of the different independent variables, multiple linear regression and binary logistic regression were used. The significance level was set at 0.01. All analyses were performed using SPSS version 22.0 (IBM).

3 | RESULTS

A total of 108 simulated instrumental births were assisted with forceps, with 36 simulations assisted with Simpson-Braun forceps, 36 with Kielland forceps, and 36 with Thierry spatulas. Among the six participating obstetricians, four stated that Kielland forceps were their preferred instrument for nonrotational forceps births, one obstetrician preferred the Simpson-Braun forceps, and another obstetrician favored Thierry spatulas. Of them, three had >10years of experience and three had <5 years of experience.

The highest force applied to the infant was 25.0N (15.0; 44.0N), the maximum pressure measured on the perineum was 68.5 mm Hg

(55.25; 84.0mm Hg), and the traction time was 20.5s (16.0; 28.0s). In 84 (77.8%) simulations, no difficulty was reported by the operating obstetrician. In the simulations where some difficulty was reported, in 22 (91.7%) cases, this difficulty was rated as 1 or 2 on the five-point Likert scale.

The instrument with which the greatest force was applied to the baby was the Simpson-Braun forceps (39.5 N [19.75; 50.75 N]), while the Thierrys spatulas exerted the least force (16.5 N [10.0; 24.0 N]) (Table 1). The force exerted with Thierry spatulas was significantly lower than that exerted with Simpson-Braun and Kielland forceps ($P<0.01$).

Regarding perineal pressure, the lowest pressure occurred in simulations assisted with Kielland forceps (63.5mm Hg [48.25; 75.5mm Hg]), although the difference was not statistically significant compared with the other two instruments ($P=0.059$).

Regarding difficulty, there were more simulations with any kind of difficulty in the group of births with Thierry spatulas (10 births [27.8%]), although the difference was not statistically significant compared with the other two instruments ($P=0.326$). There were also no differences in terms of traction time between the three instruments ($P=0.925$) (Table 1).

The recorded pressure on the perineum was lower when obstetricians used their preferred instrument compared with other instruments (61.0 mm Hg [37.5; 83.25 mm Hg] versus 71.5 mm Hg [61.25; 84.0 mm Hg], $P=0.023$). Between obstetricians with >10 years of experience and those with <5 years of experience, there were significant differences only in traction time (16.5 s [14.0; 19.0 s] vs 27.5 s [22.0; 33.0 s], $P<0.001$). After multiple linear regression to account for the obstetrician's preferred instrument, experience, and instrument used, it was found that the obstetrician's preference was independently associated with the pressure exerted on the perineum, as well as the obstetrician's experience with the time taken to perform the procedure. Meanwhile, the force applied to the infant was only independently related to the instrument used (Table 2). Regarding the presence of difficulties, after binary logistic regression, no variable was independently associated (Table 3).

When analyzing only the simulations assisted with their preferred instrument, the user who favored Thierry spatulas (<5 years of experience) applied less force on the baby (23.5 N [19.5; 36 N] vs 35 N [17.5; 48.5 N], $P=0.005$), while the user who preferred Simpson forceps (>10 years of experience) exerted lower perineal pressure (23.5 mm Hg [19.5; 36 mm Hg] vs 67 mm Hg [48.75; 90 mm Hg], $P<0.001$).

4 | DISCUSSION

Obstetric forceps come in various designs, and the choice of one over the other can significantly impact real-life outcomes. Among the three forceps studied, there are notable differences in both their design and performance. It is crucial to recognize that these instruments may not always perfectly accommodate the interaction between the maternal pelvis and the fetal head. The cephalic curvature may not universally accommodate all fetal head shapes, and, likewise, the pelvic curvature may not align with every type of pelvis. In our study, the Thierry spatula exhibited less traction force and the Kielland forceps exerted less pressure on the perineum. However, the best outcome for the perineum was achieved by an experienced obstetrician using the Simpson-Braun forceps.

The three studied instruments show little variation in terms of safety according to various studies.^{1,3,11,13} Their selection for use often relies on training and tradition. In our study, we did not detect significant differences in perineal pressure. However, the outcomes of the user who preferred the Simpson forceps were noteworthy. This leads us to contemplate whether the pelvic curvature of the Simpson-Braun forceps might support the Pajot-Saxtorph maneuver.¹⁰ This potential alignment could redirect force vectors away from the perineum by elevating the branches

TABLE 2 Multiple linear regression of variables predicting the force exerted on the baby, pressure on the perineum, and traction time.

| Linear regression of variables predicting the force exerted on the baby | | | | | | | |
|---|----|--------|------|---------|--------|------------------|---------|
| Variable | | B | SE | β | t | 95% CI for B | P value |
| Instrument | D1 | 20.47 | 3.56 | 0.55 | 5.74 | (13.40–27.54) | <0.001 |
| | D2 | 15.53 | 3.98 | 0.42 | 3.90 | (7.63–23.43) | <0.001 |
| Preference | | 0.71 | 3.56 | 0.02 | 0.20 | (–6.35–7.78) | 0.842 |
| Experience | | –5.50 | 2.91 | –0.16 | –1.89 | (–11.27–0.27) | 0.062 |
| Constant | | 20.24 | 2.97 | – | 6.81 | (14.35–26.13) | <0.001 |
| Linear regression of variables predicting the pressure on the perineum | | | | | | | |
| Variable | | B | SE | β | t | 95% CI for B | P value |
| Instrument | D1 | –7.97 | 5.34 | –0.16 | –1.49 | (–18.56–2.61) | 0.138 |
| | D2 | –7.40 | 5.97 | –0.15 | –1.24 | (–19.24–4.43) | 0.218 |
| Preference | | –11.08 | 5.34 | –0.22 | –2.08 | (–21.67–(–0.50)) | 0.040 |
| Experience | | 1.80 | 4.36 | 0.04 | 0.41 | (–6.84–10.44) | 0.681 |
| Constant | | 76.84 | 4.45 | – | 17.28 | (68.02–85.66) | <0.001 |
| Linear regression of variables predicting the traction time | | | | | | | |
| Variable | | B | SE | β | t | 95% CI for B | P value |
| Instrument | D1 | –0.03 | 1.30 | –0.002 | –0.02 | (–2.61–2.56) | 0.983 |
| | D2 | –2.66 | 1.46 | –0.16 | –1.82 | (–5.55–0.23) | 0.071 |
| Preference | | 3.27 | 1.30 | 0.20 | 2.51 | (0.68–5.86) | 0.014 |
| Experience | | –10.94 | 1.06 | –0.70 | –10.28 | (–13.06–(–8.83)) | <0.001 |
| Constant | | 27.68 | 1.09 | – | 25.46 | (25.52–29.83) | <0.001 |

Note: Instrument: Simpson forceps (D1=1; D2=0), Kielland forceps (D1=0; D2=1), and Thierry spatulas (D1=0; D2=0). Preference: whether the instrument is preferred (preference=1) or not (preference=0). Experience: >10 years (experience=1) or <5 years (experience=0).

Abbreviations: CI, confidence interval; SE, standard error.

TABLE 3 Binary logistic regression for the presence of difficulties during the simulations.

| Variable | | B | SE | OR | 95% CI | P value |
|------------|----|-------|------|------|---------------|---------|
| Instrument | D1 | -0.30 | 0.55 | 0.74 | (13.40-27.54) | 0.585 |
| | D2 | -0.65 | 0.65 | 0.52 | (0.15-1.85) | 0.314 |
| Preference | | -0.01 | 0.58 | 0.99 | (0.31-3.10) | 0.983 |
| Experience | | -0.44 | 0.47 | 0.65 | (0.26-1.63) | 0.353 |
| Constant | | -0.74 | 0.44 | 0.47 | - | 0.093 |

Note: Instrument: Simpson forceps (D1 = 1; D2 = 0), Kielland forceps (D1 = 0; D2 = 1), and Thierry spatulas (D1 = 0; D2 = 0). Preference: whether the instrument is preferred (preference = 1) or not (preference = 0). Experience: >10 years (experience = 1) or <5 years (experience = 0).

Abbreviations: CI, confidence interval; OR, odds ratio; SE, standard error.

along the Carus curve earlier along the axis established by the pubic symphysis.

The result obtained with Thierry spatulas in terms of the force exerted on the baby is significant. The French College of Gynecologists and Obstetricians emphasizes in their clinical guidelines that, attributable to the propulsion mechanism, the likelihood of harming a baby with this instrument is highly improbable.⁸ Given that theoretically less force is applied with this instrument, it has been proposed as the instrument of choice in premature births, especially considering that obstetric vacuum extraction is contraindicated before the 35th week of gestation.¹⁴ A study comparing forceps with spatulas in premature infants found no disparities in maternal-neonatal morbidity but did observe a lower rate of episiotomy with spatulas.¹⁵ Our study indeed demonstrates that Thierry spatulas exert less traction force compared with Kielland and Simpson forceps.

It was surprising that there were no significant differences between more experienced and less experienced obstetricians, except for the traction time. However, we know that speed is a factor that exerts a significant influence on force.¹⁰ We believe this can be explained by better technique on the part of more experienced obstetricians, but it may have been overshadowed by the faster execution of the maneuvers. Therefore, it shows the importance of performing tractions slowly and gently. As for the better technique, it is important to emphasize that the rate of assisted births has been rapidly decreasing in recent years, and even more so assisted births with forceps, which may also explain changes in technique between experienced and younger professionals.¹⁶

Regarding the difficulty level, an assisted birth with forceps should ideally be straightforward, or the procedure should be abandoned.⁵⁻⁸ In our study, there were no cases with a high degree of difficulty with any of the three forceps studied, nor were there any differences in the rate of reporting any difficulty. We believe this can be explained because the technique of a nonrotational forceps is not complex and is similar across different instruments. Therefore, we believe that an obstetrician should not shy away from using different instruments.

When it comes to the study's strengths, it is the first to our knowledge to investigate various forceps, analyzing the two primary risk factors: traction force and perineal pressure. While a similar approach has been used in studies of the Odon device, it did not

distinguish between various types of forceps.¹⁷ Furthermore, the use of simulation ensures that biomechanical and anthropometric characteristics are consistent in each birth scenario, effectively mitigating potential selection biases.

The main limitation of the study is that pressures on the lateral and anterior walls of the birth canal were not evaluated. Another weakness is that, since the simulator did not require an episiotomy, it was not assessed whether performing an episiotomy could affect the differences in biomechanics among the various studied forceps.

In conclusion, Thierry spatulas exert the least force on the fetal head. Regarding perineal pressure, it appears that an experienced operator applies less pressure with the Simpson forceps. The Kielland forceps is a viable option, showing marginal differences compared with the Simpson forceps and Thierry spatulas in nonrotational forceps.

AUTHOR CONTRIBUTIONS

MJC: protocol/project development, data collection, manuscript writing. PV: protocol/project development, data analysis, manuscript writing. MC: protocol/project development, data collection, manuscript editing. CP: data collection; manuscript writing/editing. MPDA: data collection; manuscript writing/editing. MC: data collection; manuscript writing/editing. FL: data collection; manuscript writing/editing. JLB: protocol/project development, validation of data analysis, manuscript reviewing and editing. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work and agreed to be accountable for all aspects of the work.

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CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflicts of interest.

DATA AVAILABILITY STATEMENT

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

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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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