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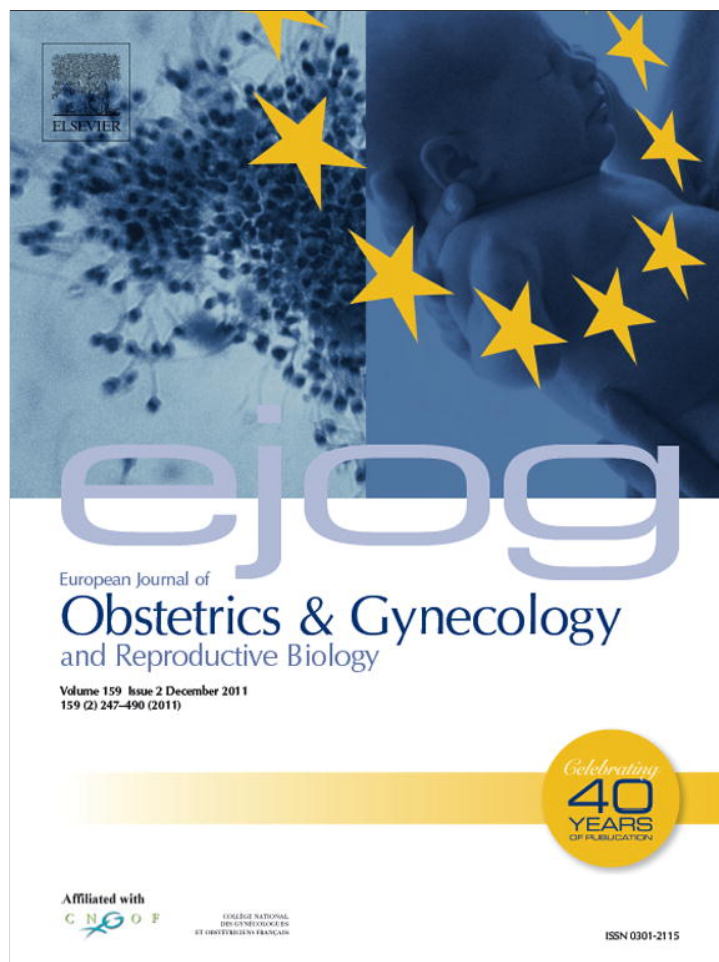
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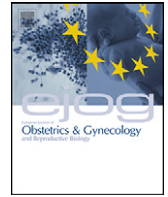
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Does forceps training on a birth simulator allow obstetricians to improve forceps blade placement?

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ABSTRACT

Objective: The aim of this study was to evaluate whether forceps training on a birth simulator allows obstetricians to improve forceps blade placement.

Study design: Analysis was based on 600 forceps blade placements performed by ten trainees on a simulator. The trajectories used by the trainees were assessed using reference spheres that reflected an optimal bimalar placement. Three definitions of success were used: small-sphere success, medium-sphere success and large-sphere success were respectively defined by the forceps blade tip being within 5, 10 or 15 mm of the center of the sphere (the small-sphere being nested within the medium-sphere and the small and medium being nested within the large-sphere). Wilcoxon paired analysis was performed to compare the first (50 trajectories) and final (50 trajectories) sets of five forceps placements. Graphical representation and linear regression were used to visualize the learning process.

Results: 596 trajectories were available for analysis. During the last set of five forceps the success rate was respectively 28%, 72% and 86% for small-sphere, medium-sphere and large-sphere success with the right blade and 8%, 32% and 70% for the left blade. Wilcoxon analysis showed a highly significant improvement for all kinds of success in the right blade and for large-sphere success in the left blade. Linear regression slopes were significant. Using a projection, the theoretical numbers of placements needed to achieve a 100% success rate for small-sphere, medium-sphere and large-sphere were respectively 80, 45 and 35.

Conclusion: These results strongly suggest that performing forceps blade placement on birth simulator allows obstetricians to improve their skills.

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1. Introduction

In 2005, 198,000 infants were delivered by either forceps or vacuum extraction in the USA [1]. Operative vaginal delivery training still relies on traditional training, which is confronted by several constraints. Spatial constraints involve the operators who only have limited visual access to the pelvic canal, whereas time constraints occur whenever the delivery occurs in an emergency setting. These limitations have been further aggravated by less time dedicated to training, and increased litigation rates.

Any significant delay sustained by the fetus exposes it to an acute state of anoxia that may lead to death or life-long disabilities

[2,3]. Faced with this situation, obstetricians who choose the vaginal route have only one solution: operative vaginal delivery. Studies have suggested that the vacuum leads to a significantly lower rate of anal sphincter tearing [4–6], several teams therefore adopt the vacuum as the “First line” method, and, in case of failure, then try a “second line” forceps delivery [7,8]. Compared with vacuums, the failure rate is significantly lower with forceps [9]. This strategy may explain the decreasing rate of forceps deliveries [10] but leads to a major disadvantage: loss of skills with regard to forceps delivery [11].

Training by means of simulation removes traditional limitations making it possible to both avoid exposing pregnant woman to the hazards of training, and adapt the training to the skills of each trainee. Such training has been promoted by the National Academy of Sciences [12]. Our team has designed a simulator that tracks the forceps trajectories and enables trainees to record and visualize their trajectories [13].

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The aim of this study was to evaluate whether forceps training on a birth simulator allows obstetricians to improve their skills in forceps blade placement.

2. Materials and methods

2.1. Material

This study used the 2008 version of the BirthSIM simulator [13]. The fetal head, maternal pelvis and forceps are “real” and also displayed on a screen. Both blades of a non magnetic crossed shanks forceps (Levret forceps) are equipped with electromagnetic spatial location sensors. These sensors track the real time position and orientation of each point of the fetal head and forceps. Three software applications were used. The first managed the data for the head’s position, the second provided real time visualization of both forceps blades and of the head, and the third recorded blade tip trajectories and displayed the reference spheres (Fig. 1).

According to classic obstetrics textbooks, forceps blades were considered well placed when “the tips of the blades lie over the cheeks of the fetus” with a bimalar cephalic application [14,15]. Reference spheres (RS) were thus defined: the centers of those spheres were located in order to match with a bimalar forceps blade location. Appropriate diameters of the RS were based on the security distance that should be respected between the tip of the forceps and the eye of the fetus, as well as the facial nerve. An anthropometric study performed on 50 full term neonates (Fig. 2) showed that the distance between the tip of the forceps blade and the eye or facial nerve was always more than 2.9 cm, thus producing a “large” sphere 3 cm in diameter around the ideal point for obtaining a 14 mm (29–[30/2]) safety margin and was considered safe.

The location of the tip is considered safe if it is within a sphere of 15 mm of the center of the RS. We analyzed the data according to this safe sphere but we also provided analysis on more restrictive spheres.

We defined 3 kinds of success (Fig. 1) based on the location of the tip of the forceps blade



Fig. 2. Anthropometric study: (1) distance between external corners of the eye – tip forceps, (2) distance between stylomastoid emergences of the facial nerve – tip forceps.

- “small-sphere” success (yes/no): it was obtained if the tip was located within a small reference sphere (within 5 mm of diameter of the center of the RS),
- “medium-sphere” success (yes/no): it was obtained if the tip was located within a medium reference sphere (within 10 mm of diameter of the center of the RS). By definition, this medium-sphere includes the small-sphere, therefore all small-sphere success are also classified as medium-sphere success,
- “large-sphere” success (yes/no): it was obtained if the tip was located within a large reference sphere (within 15 mm of diameter of the center of the RS). By definition, this medium-sphere includes the small and the medium spheres, therefore all small-sphere or medium-sphere success are also classified as large-sphere success.

According to these 3 kinds of success, a placement located between 0 and 5 mm will be considered as successful whatever the definitions used (this placement will be classified as a small-sphere success, as a medium-sphere success since small-sphere is nested within medium-sphere, and also as a large-sphere success since small-sphere is nested within large-sphere). A placement located between 5 and 10 mm will be considered as a medium-sphere success and also a large-sphere success. A placement located between 10 and 15 mm will only be considered as a large-sphere success. Lastly, a placement beyond 15 mm will never be considered as a success whatever the definition used; this placement will be considered as “failure”.

3. Methodology

Ten trainees were asked to participate in two 60 min sessions (Fig. 3). As this study was performed on an inanimate simulator, no ethics committee approval was requested.

During the experiment, the trainees were asked to perform a clinical examination and then to perform forceps blade placements. Two sessions were held, seven days apart, during which the trainees placed the forceps blades 15 times. This yielded a total of 60 trajectories for each trainee, 30 right and 30 left. The choice of this training scheme was made for practical reasons.

For each simulation, the head of the fetus was on an outlet (+4) [16], occipital–anterior position and exhibited no asynclitism, caput succedaneum or moulding mimicking a non rotational outlet delivery.

During forceps placement, the teacher used two monitors, one providing the precise location of the head and allowing the experiment to be reproducible, the second screen providing the

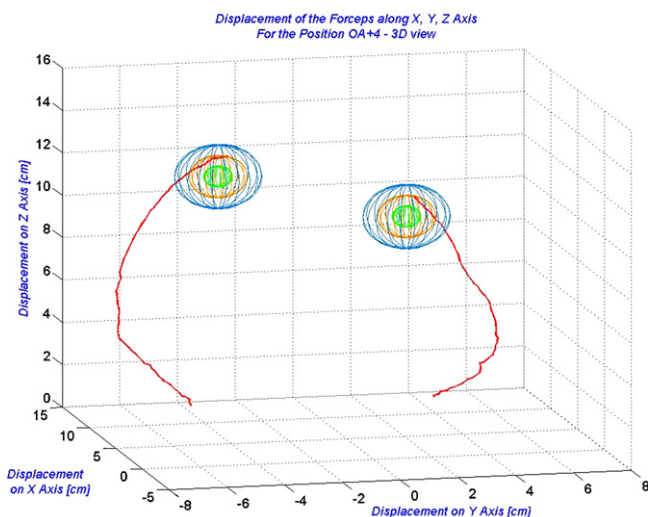


Fig. 1. Trainee blade tip trajectories (red). The three dimensional large (blue), medium (red) and small (green) spheres are presented on the left and right sides. (The X-axis is horizontal longitudinal, craniocaudal, the positive direction is going towards the maternal head, the Y axis is horizontal and transverse and runs from left to right, it is positive between the median point and the right. The Z-axis is vertical and positive in the upward direction.). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of the article.)

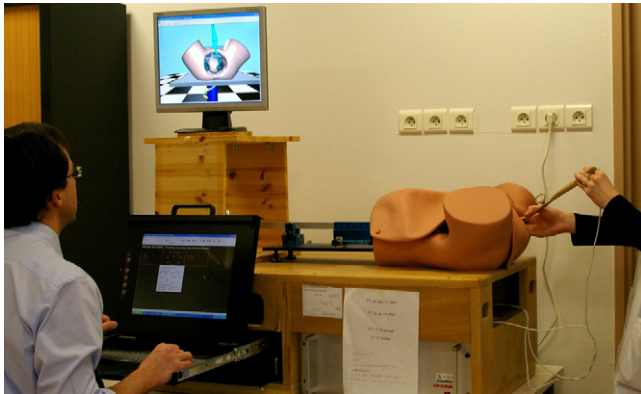


Fig. 3. Picture of a trainee undertaking the exercise with the teacher.

real time display of the forceps blades and the head of the fetus. The trainee was unable to see those monitors. At the end of every five forceps placements, the trajectories of the blade tips and the RS were displayed and discussed. The next set of five forceps placements was then performed. Therefore, placements within sets were considered as correlated, and each set of five placements was considered as independent, even if they were performed on the same day.

The recording protocol was the following: as soon as the trainee was ready to start the forceps placement, the first recording began and was stopped when the trainee said that the left blade was in the appropriate location. Then the trainee put down the left blade and took up the right blade, and the second recording began, ending when the two forceps blades were locked and when the trainee said that the whole instrument was in the appropriate location. For each experiment, the resident had two results, one for each blade, with each side reaching a small, a medium or a large-sphere.

4. Statistics

SAS statistical software was used. Data were analyzed from two perspectives: individual and population. For an individual perspective, the first set of five forceps blade placements and the last set of five forceps blade placements were compared using the Wilcoxon signed rank test for paired data. We also compared the last set of five placements of the first day to the first set of five placements of the second day. For the population perspective, we used graphics to visualize the learning process. We also adjusted a simple linear regression analysis to see if, from the 6 sets of 5 placements, there was a tendency to improve the overall level of expertise. Using regression equations, we defined the theoretical number of sets needed to achieve a 100% success rate in a set. The level of confidence was set at 0.05.

Table 1
Type and number of successes throughout the training process.

Forceps side	Type of success ^a	Number of successes in the 298 placements n (%)	Success in the 50 placements of first set n (%)	Success in the 50 placements of the last set n (%)	Average gain per student between first and last sets	Paired analysis p value ^a
Left blade	Small-sphere	16 (5)	0 (0)	4 (8)	+0.4	0.50
	Medium-sphere	72 (24)	5 (10)	16 (32)	+1.1	0.19
	Large-sphere	147 (49)	16 (32)	35 (70)	+1.9	0.03
Right blade	Small-sphere	54 (18)	2 (4)	14 (28)	+1.2	0.02
	Medium-sphere	145 (49)	15 (30)	36 (72)	+2.1	0.03
	Large-sphere	204 (68)	23 (46)	43 (86)	+2.0	0.04

^a Small-sphere success = tip located within a sphere of 5 mm of diameter; medium-sphere success = tip located within a sphere of 10 mm of diameter (including the small-sphere); large-sphere success = tip located within a sphere of 15 mm of diameter (including the small and the medium spheres).

5. Results

The study took place in the obstetrical department of Lyon Sud University hospital. Between July 2007 and February 2008, 10 trainees were involved. None of the trainees had used the Birth simulator before the study; eight trainees had no experience in forceps blade placement and two had very limited clinical practice i.e. being in their first year of training and being unable to perform forceps placement without close supervision. Five out of 10 trainees were male, all were right handed, and the mean age was 23.9 years.

Of the 600 trajectories recorded, two sets of trajectories were lost during the computerization process, leaving 596 trajectories for analysis.

The type and number of successful placements attained by the trainees during the complete training and during the first and final sets of five forceps placements were analyzed (Table 1). During the last set of forceps placements, the trainees respectively obtained a 28%, 72% and 86% rate of small-sphere, medium-sphere and large-sphere success for the right blade and an 8%, 32% and 70% rate for the left blade. Wilcoxon paired analysis showed a highly significant improvement for any kind of success in the right blade and for large-sphere success in the left blade. There was no significant difference between the last set of placements of day 1 and the first set of placements of day 2 (data not shown).

For the right blade, small-sphere success was attained in 3–40% of the trajectories, depending on the trainee, medium-sphere success from 10% to 67% and large-sphere success from 27% to 93% of the trajectories. For the last set of 5 forceps placements on right blade, 7 of the 10 trainees had 5 large-sphere successes (i.e. 100% success), of which 5 also had a 100% success for medium-sphere. For the left blade, small-sphere success was attained in 0–17% of the trajectories, medium-sphere success from 3% to 50% and large-sphere success from 23% to 73% of the trajectories. During the last set of 5 forceps placements, 2 trainees had a 100% success for the large-sphere. Fig. 4 shows the number of trainees attaining small-sphere, medium-sphere or large-sphere success throughout the entire training process. After 15 forceps blade placements, more than 50% of the trainees had large-sphere right blade success. The first small-sphere, medium-sphere and large-sphere successes were attained for the right blade after on average 14.9 (sd: 7.5), 4.4 (4.4) and 3.9 (4.3) blade placements, respectively.

Fig. 5 shows both the overall success rates for right forceps throughout the 6 sets of 5 placements and the linear regression lines. The linear regression slopes were significant. Using a projection, we defined the theoretical number of sets needed to achieve a 100% success rate in a set for small-sphere, medium-sphere and large-sphere success as respectively 16×5 (80 placements), 9×5 (45) and 7×5 (35).

There were 94 trajectory failures (beyond 15 mm of diameter) for the right blade versus 151 for the left blade ($p < 0.001$). Of the 151 left trajectory failure, 78 (51.7%) were associated with some degree of success with the right blade.

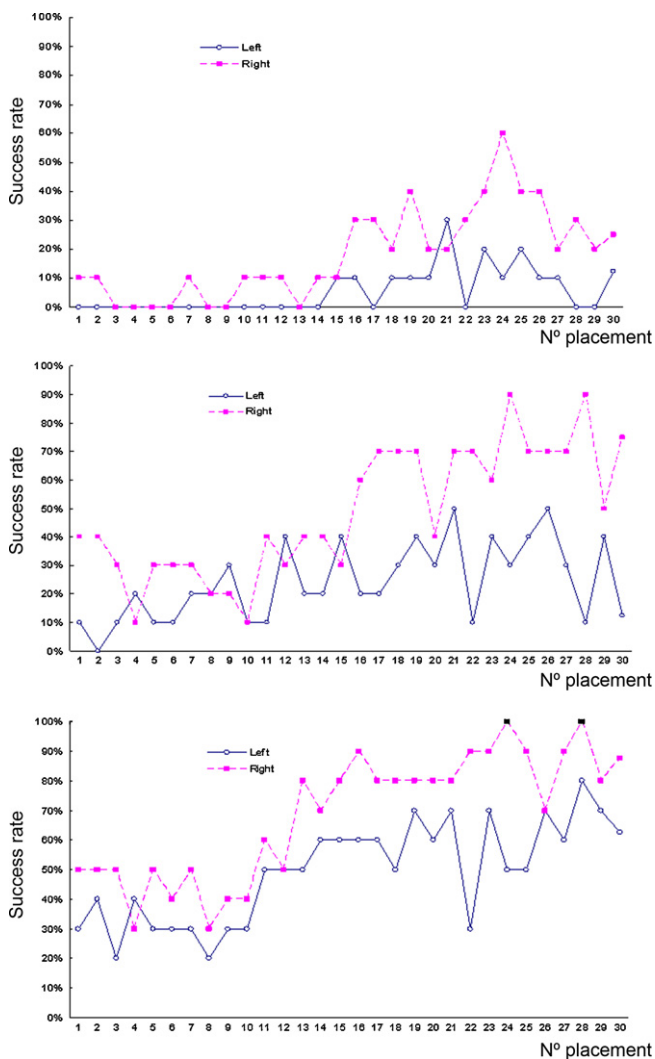


Fig. 4. Number of trainees obtaining (a) small-sphere success, (b) medium-sphere success, or (c) large-sphere success at each forceps placement (8 students for attempt no. 30).

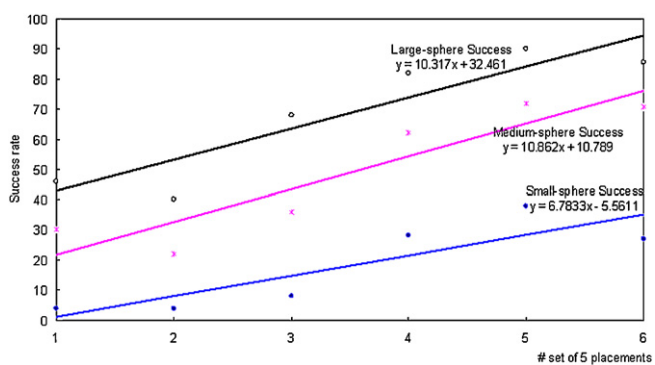


Fig. 5. Success rate for each set of five placements for the right forceps blade (only 48 attempts for set no. 6) and linear regression analysis (X is the number of forceps blade placements, and Y the success rate that was expected. *p*-Value for slopes: small-sphere success = 0.03; medium-sphere success = 0.01; large-sphere success = 0.01).

6. Discussion

As recently as 2005, operative vaginal delivery skills were compared to artistic skills that could not be precisely assessed [17]. Skills have been assessed using a self-reported competency

questionnaire [18,19], or simple observation by a senior obstetrician [20]. Such evaluations were subject to observation bias. One study reported an objective evaluation of traction forces produced, but this study dealt with the amount of traction forces developed and not with the quality of blade placements [21]. The simulator made it possible to record and compare the trajectories of both trainees and experts [13]. Some teams have chosen to define “expert” as operators who use forceps over a period >10 years for >90% of operative vaginal deliveries, whereas others have defined “expert” as board certified obstetricians [22]. As no one has yet defined an expert we chose not to rely on “experts” but, instead, to focus on anatomical landmarks. The analysis was computer driven and thus provided an objective evaluation of skills. The fact that 99.3% of the trajectories were available for discussion with the trainee showed that there was a high degree of feasibility. Trainees were pleased to get visual feedback using a 3D recording of the forceps blade trajectories, as well as the RS, and thus to debrief their procedures. In 2000, the National US Academy of Sciences identified five principles that can be usefully applied to the design of safe healthcare: one of those five principles is “to create a learning environment” and “use of simulations whenever possible” [12]. We believe that such training partially fulfills this goal.

In the clinical circumstances of severe fetal compromise, any significant delay (due to failure in operative vaginal delivery) may expose the fetus to an acute state of hypoxemia and to neonatal death [3]. Failure may be the result of an inability to apply the instrument, or a lack of descent with traction [3,4,7,23–25]. With regard to forceps, the most frequent reason for failure is poor forceps placement [25–27] and hence the inability to articulate the forceps blades. For Williams and Bofill, failed forceps blade application accounted respectively for 91% and 83% of failures [4,25]. Furthermore, forceps blade placement should not only be possible, but also correctly placed, as symmetric application should ensure that the instrument does not touch the eyes, neck or facial nerve. At the end of the training trainees had significantly improved for all types of success for the right blade and for large-sphere success in the left blade. This study suggests that such training significantly enhances trainee skills. Prospective studies will be needed to demonstrate whether it decreases forceps failure rates.

This study highlights the fact that trainees displayed a wide range of skills: at the end of the training process, 7 out of 10 trainees had obtained 5/5 large-sphere success although three trainees did not attain the 5/5 success rate. As shown by the value of the standard deviation, there was a significant difference in the number of placements needed to ensure success between the trainees. This point might explain why, in the reality of a labor ward, close supervision of trainees should be provided. The main goal of program directors is to get 100% of trainees to fulfill this task. This study suggests that training in obstetrics skills might be considered at an individual, rather than at a group, level.

The minimum number of procedures that should be performed by trainees before certification is a major concern for obstetricians. This study showed that 7 sets of five forceps placements had to be performed by each trainee in order to be sure that the less-skilled trainees had attained a 5/5 large-sphere success level for an occipito anterior forceps delivery. With a rate of 9 forceps deliveries a year, this means that trainees could be considered well-trained during their fourth year of traditional training. It should be noted that this number of forceps placements was required to obtain adequate placement in an occipito anterior location. Oblique placement needed different skills. It could therefore be suggested that perhaps around twice as many (i.e. 14 sets), may be required to

ensure adequate training. This type of goal is easily satisfied using both traditional and simulation training, but seems unfeasible with traditional training alone. As stated in the method section a large-sphere success allows to get a 14 mm safety margin between the tips of the forceps and the neonate eye and facial nerves, but one should keep in mind that this is a theoretical safety concept. Because no method is currently available to compare simulated forceps placements and real forceps placements, our results should be interpreted with caution.

Finally, this study showed different results for the right and left blades: missed trajectories were 1.6 times more frequent with the left blade, and Wilcoxon analysis showed a highly significant improvement for every type of success for the right blade, whereas left blade improvement was restricted to the large-sphere success type. This could be explained by the recording protocol as well as the forceps design. The recording of the blades' trajectories was sequential: the second blade (i.e. right blade) thus reflected not only the blade itself but the trajectory of the fully locked instrument. In other words, "right blade" successes were in fact "instrument placement success" whereas "left blade" successes were only "blade placement successes". This explains why more than half of the apparent left trajectory failures were associated with right blade success. This study revealed the outstanding intrinsic quality of forceps, namely their ability for automatic quality control via the locking mechanism: no forceps can be used if the instrument is not locked i.e. if the two blades have not been applied symmetrically.

In delivery wards where vacuum and forceps delivery are practiced the difficulties of achieving competence in both techniques will be compounded even further. Since the respective techniques of forceps delivery and vacuum extraction are completely different, it is important for trainers to realise that experience in the correct use of forceps will not transpose to correct vacuum delivery technique. A specific training is needed for each instrument.

This study has several limitations. In order to be used properly, forceps delivery requires not only appropriate left and right blade placement but also appropriate range of force traction, appropriate axis of traction and an appropriate synchronisation. Hence operative vaginal delivery should not be considered as a simple procedure but rather as a highly complex procedure. Junior obstetricians could correct placed the forceps blades but generated traction forces in excess of the recommended 45 lb [21]. The quality control procedure that was developed here should thus be associated with axis of traction synchronisation and force training [21]. Some obstetricians will argue that no definite conclusion can be drawn with such experimental studies and that prospective studies should compare two groups of trainees, one with conventional training and one with conventional plus simulation training, or compare in an observational retrospective study maternal as well as neonatal outcomes before and after the introduction of a training course. In terms of shoulder dystocia, a study has recently shown that simulation training was associated with improved neonatal outcomes [28].

In conclusion, this study suggests that forceps training on a simulator makes possible improvement in obstetricians' skills. It also exhibits the wide variability of manual skills provided by trainees. We believe that such training could improve obstetrics training and reduce training-related risks.

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