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Forceps Use in Rotational and Non-Rotational Vaginal Delivery

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ABSTRACT

Forceps are a commonly used instrument for assisting vaginal delivery. Accepted indications include prolonged labour, suspected fetal distress and maternal medical conditions that benefit from a shortened second stage of labour. Maternal and offspring outcomes of forceps-assisted birth have been extensively reported in observational studies, but randomized trial evidence is limited. Forceps-assisted delivery has a lower failure rate than vacuum-assisted delivery but is associated with a higher incidence of maternal pelvic floor trauma. Second-stage caesarean section is associated with less fetal-neonatal trauma than forceps-assisted delivery but markedly reduces the chance of a subsequent vaginal birth. This review outlines the existing evidence on prevention, indications, and contraindications for forceps-assisted birth (non-rotational and rotational), short- and long-term complications for mother and baby, alternatives to use of forceps and how to manage an abandoned forceps-assisted birth. The essential components of informed consent are also discussed.

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Introduction

The obstetric forceps is used to speed up vaginal delivery whenever an expedited delivery is necessary both for maternal or fetal indications. In the UK the rates of operative vaginal delivery range between 10% and 15%, and more than a half of them is by forceps [1,2]. Both regional and personal preference variation are present. Usually, the forcipes are easily available in the delivery rooms of low-, middle- and high-income obstetric departments and they can be safely used by trained doctors and, in some case, also by midwifes [3]. Forceps delivery takes more or less the same time as a vacuum extraction, and since it can be done in delivery room is by far quicker than a cesarian section which requires an operating theatre (15 vs 30 minutes) [4]. Before starting an operative delivery, it's always mandatory to have the woman's informed agreement, to explain to her the pros and cons of this procedure and to kwon her medical history [5].

Practice guidelines are fundamental to support the clinical assistance with operative vaginal birth since most of those procedures' aspects are based on experts' opinion. The first classification of forcipes vaginal birth had been made by the American College of Obstetricians & Gynecologists (ACOG), and then utilized also by the Royal College of Obstetricians and Gynecologists (RCOG) [5,6].

This classification is based on the station of the fetal head at application and on the degree of rotation necessary for delivery. Studies have shown that the lower the fetal head station and the less rotation required, the lower the incidence of maternal and fetal injury during forceps-assisted delivery [7,8].

Outlet Forceps	Low Forceps	Midforceps
Fetal scalp is visible at the introitus without separating the labia. Fetal skull has reached the pelvic floor. Fetal head is at or on perineum. Sagittal suture is in an anteroposterior diameter or right or left occiput anterior or posterior position. Rotation does not exceed 45°.	Leading point of the fetal skull is at station +2 cm or more and not on the pelvic floor. Without rotation: Rotation is 45 degrees or less (right or left occiput anterior to occiput anterior, or right or left occiput posterior to occiput posterior). With rotation: Rotation is greater than 45 degrees.	Station is above +2 cm but head is engaged.

Box 1: Criteria for types of forceps deliveries by acog 2015.

Indications of Use

The indications for forceps delivery are mainly three: delay in the second stage of labor, suspicion of immediate or potential fetal compromise and maternal condition which would benefit of a shortened second stage [9-11]. Although controversial, if the fetal head is engaged, the forceps can be applied after a failure or abandon trial of operative vaginal birth with vacuum extractor.

Prolonged Second Stage of Labor

Second stage of labor may get prolonged because of poor expulsive efforts, cephalopelvic disproportion (CPD) or abnormal fetal position (OT occipitotraverse and OP occipitoposterior). Diagnosis and management of prolonged second stage of labor and its complications is difficult.

The American, English and Canadian guidelines define a prolonged second stage of labor as longer than 3+1 hours (one hour for epidural analgesia) for nulliparous and 2+1 hours (one hour for epidural analgesia) for multiparous (considering both act and passive phases of labor) [6-13].

The NICE's guidelines consider only the active phase of the second stage of labor: nulliparous women should not actively push for more than 2 hours and multiparous women for more than 1 hour [13].

A prolonged second stage of labor is an appropriate indication for operative vaginal delivery by forceps only if there is no doubt for absolute CPD [5,6,9,10]. The lack of fetal head engagement may suggest a disproportion between fetal head and perineal dimensions: in this case it is more likely to have a failure of OPB, a traumatic complication or shoulder dystocia. A possible cause of CPD is fetal Macrosomia, in absence of recent ultrasound exam this must be evaluated by clinical examination.

To understand if the head is engaged in the pelvis, a deepened abdominal (maximus 1/5 of head palpable) and vaginal (anterior part of skull at the level of ischiatic spines) examination is needed. In case of abnormal fetal position, it is more difficult to understand if there is an CPD, so the malposition correction with a traction could be necessary to test the pelvic capacity: if fetal head isn't occiput anterior it can be rotated manually or with a rotational forceps, at this point if it gets engaged into the pelvis the procedure is willing to be safe.

Fetal Compromise

The currently primary tool for the suspect of fetal distress is Cardiotocography (CTG). In case of an acute pathological CTG or a chronic CTG alterated pathway associated with abnormal ST or fetal scalp PH analysis, an expedited delivery could be indicated [14,15]. Other concerns could be meconium-stained amniotic fluid or maternal hyperpyrexia. Whenever prerequisites are checked an operative vaginal delivery can be performed.

Maternal Factors

There are also maternal medical conditions which would benefit from a shortened second stage of delivery, such as cardiological disease with limited cardiac output (ex. Aortic stenosis), significant hypertension, spinal cord injury with risk of autonomic dysreflexia, myasthenia gravis, proliferative retinopathy, antepartum hemorrhage, or exhaustion of maternal effort [5].

Failed Operative Vaginal Birth with Vacuum Extractor

In the last years a greater preference for ventouse as first aim has brought to a more frequent sequential use of forceps after a failed operative vaginal birth with vacuum extractor, with an increase of maternal and fetal traumatic events [16,17]. However, this could avoid a potentially complex cesarean section.

Contraindications

Fetal Conditions

Forceps should be avoided if the risk of fetal lesions is too high. This occurs for example in case of osteogenesis imperfecta and bleeding disorders, such as Haemophilia or Von Willebrand disease [5, 6]. Osteogenesis imperfecta is a bone demineralization condition, that places a fetus at high risk of fetal bone fractures and injury to surrounding tissues during forceps birth. Bleeding disorders exposure a fetus to the risk of cerebral hemorrhage with intracranial or extracranial hematoma formation and consequent coagulopathy.

Cephalopelvic Disproportion (CPD)

Operative vaginal birth is contraindicated if the fetal head is unengaged (2/5 or more palpable abdominally and/or standing over the maternal ischial spines) or in case of excessive caput and molding, as they constitute a CPD's suspect. Instead, signs of CPD that develop during an attempted perform of forceps-assisted delivery are failure to descend progressively with each pull or not imminent delivery after three pulls with correctly applied forceps by an expert provider [6]. A skilled operator who suspects CPD will move the patient to the operating room and diagnose CPD after one or at most 2 tractions with a well applied instrument. This is what is meant by a "forceps trial" with a low threshold to proceed to C-section. If the position of the fetal head is not known, delivery should not be performed with forceps as this presents an unacceptable risk of fetal injury to the fetal face, eyes, ears, and skull.

Forcipes Delivery Prevention

There is evidence to suggest that forceps are less likely to be needed when support is provided during labor and when low-dose epidural anesthesia is used [10-18].

Delayed Pushes

A randomized study in the United States demonstrated that forceps application is less likely to be necessary in nulliparous women with epidural analgesia who waited 2 h before actively pushing in the second stage of labor [19]. However, a more recent US study has questioned this finding, reporting that among nulliparous women receiving neuraxial analgesia, pushing times during the second stage of labor do not affect the rate of spontaneous vaginal delivery [20].

Labor Induction

The association between labor induction and assisted vaginal delivery is controversial. A Cochrane review of over 12,000 women reported that labor induction leads to a modestly increased risk of forceps or vacuum assisted delivery {RR 1.10 (1.00-1.21)} [21]. However, this association has been questioned by the results of a recent high-quality randomized controlled trial investigating low-risk pregnancies, women with macrosomal fetuses, and women older than 35 years. Each of these studies did not demonstrate an increased risk of operative vaginal delivery after labor induction [22-24]. This raises the possibility, as with results with delayed versus immediate pushing, that the association may be with high-dose epidural techniques with heavy blockage once used, rather than labor induction.

Labor Management

Practices that have been shown to be ineffective in reducing OVB rates are the use of partogram, early artificial rupture of membranes (ARM), avoidance of an epidural before cervical dilatation of 3 cm and walking during labor [10]. The BUMPES study reported that standing with epidural anesthesia did not reduce the rate of POV and indeed the rate of spontaneous vaginal delivery is higher in lateral lying positions [25,26]. It is currently unclear whether manually rotating a mispositioned fetus from posterior to anterior reduces POV, but several randomized controlled trials are underway to test this hypothesis [27,28].

Forceps Option

When considering a forceps-assisted delivery, the risks and benefits of the possible options should be considered. Alternatives include pending management of a spontaneous vaginal delivery, vacuum assisted delivery, or a cesarean section in the second stage.

When to Intervene

The choice of intervention to hasten birth should reflect the clinical circumstances of the case as none of the options are, with certainty, safer than the others. The advantages and disadvantages of each choice are related to maternal and fetal conditions, the stage of labor and the woman's values and preferences. The time between the decision to deliver and the delivery itself (decision-to-delivery interval DDI) appears particularly important when compromised fetal conditions are suspected [4].

Qualitative evidence from a simulation study of ten experienced obstetricians demonstrated that clinicians consider a multitude of factors before deciding when, how and where to conduct an assisted vaginal delivery and who should be present at the birth. Influent factors include whether the fetus shows signs of distress, whether contractions are adequate or maternal pushing is effective, whether head descent is impeded and arrested by the perineum, and the position and station of the fetal head [29]. For example, if a fetus is not stressed, the woman is tired but continues to push effectively, the vertex is just below the level of the ischial spines, and she has expressed a desire to avoid the risk of OASI over any other adverse outcome, then it may be more appropriate to handle labor with a waiting behavior in the first instance.

The woman should be involved in the decision to hasten delivery and should understand the reasons, the alternatives and the risks involved. These are the essential legal components for obtaining informed consent [30,31]. The decision to perform a forceps-assisted delivery should therefore reflect an informed and shared decision. Ultimately, a conscious woman can refuse forceps assistance regardless of the potential outcome for her or her infant [32].

Instruments' Choice

The choice about the delivery management should consider which one appears most likely to be effective in achieving delivery with the least morbidity. Several randomized controlled trials and 13 studies summarized in a Cochrane review in 2010 demonstrated the major efficacy of forceps versus vacuum extractor. Forceps were shown to have a lower failure rate than vacuum extractors (RR:0.65, 95% CI: 0.45-0.94). The choice of whether to use forceps or vacuum extractors depends on multiple factors, including operator skills and preference based on experience, clinical circumstances that influence a vacuum extractor's likelihood of success (e.g., maternal effort, degree of analgesia, caput and molding) [5].

A forceps delivery takes a similar amount of time to a vacuum cup delivery, nevertheless, the provider should be aware of the higher failure rate with a vacuum cup; thus, the degree of fetal urgency may play a role in the final decision [4]. The benefit-risk profile of each delivery should be considered and, when possible and appropriate, discussed with the woman before proceeding.

Safety Prerequisites for Forceps' Use

Case-specific factors to consider when deciding to perform a forceps-assisted delivery include confirmation of key prerequisites based on expert judgment: vertex presentation; fully dilated and retracted cervix; fetal head engagement with no more than one-fifth palpable abdominally; knowledge of the position of the fetal head; membranes ruptured; degree of caput and molding assessed as not excessive; adequate pelvic size; simultaneous fetal head descent with the maternal expulsive effort; informed consent; adequate analgesia; empty bladder; achievable aseptic conditions; suitably qualified and trained clinicians; available equipment; easy switching to caesarean section; ability to manage complications and resources in advance [5].

It may be decided that a forceps-assisted delivery should be performed in an operating room where access to cesarean delivery is achievable without delay. Examples of such scenarios include the presence of caput or moderate molding, a need for fetal head rotation, or a subjective impression of suboptimal pelvic size and/or a large baby. A contingency plan should always be in place in case of failure, and this will almost always require a cesarean delivery.

Forceps Versus Cesarean Section

The decision to perform a caesarean section is supported by evidence of high head (2/5 or more palpable abdominally, vertex above the ischial spines), excessive caput or molding, no possible malposition correcting rotation or the impression of insufficient pelvic dimensions [29]. The decision whether to perform a cesarean delivery should be influenced not only by the vaginal examination but also by the clinician's experience and the woman's preferences. If the vaginal examination suggests that there is no evidence of CPD and a forceps delivery may be considered appropriate, then the decision should consider the potential morbidities. All decisions that have a potential impact on future pregnancy outcomes should be considered as long-term risks. The woman who had a successful forceps-assisted delivery has a high probability of spontaneous vaginal delivery in a subsequent pregnancy (80% versus 30%) [33]. However, a woman who had a forceps-assisted delivery complicated by significant maternal or neonatal complications is more likely to require an elective cesarean section in a following pregnancy.

Rotational Forceps

In the UK, when the cause of second stage labor dystocia is a malpositioned fetus, some obstetrician units routinely use Kielland rotational forceps (KRF). The KRF is generally suited if more than 45° is needed to reach the occipito-anterior position. Another option includes the use of a vacuum cup or manual rotation followed by direct forceps assisted delivery. Rotational forceps differ from those designed for direct traction, they are intended for use both to rotate the fetal head anteriorly and to deliver the fetal head. The KRF has a long handle with no pelvic curve to minimize maternal trauma during rotation. However, in many cases, the more commonly used KRF is not applied due to safety concerns [34]. A European study on 86 infants born with KRF reported an associated mortality rate of 3.5% and a birth trauma rate of 15% [35]. A much more reassuring safety profile for KRF has been reported in recent years. A systematic review of observational studies comparing rotational forceps versus rotational vacuum extraction demonstrated lower neonatal trauma rates (RR 0.62 (0.46-0.85, p = 0.003)) and a substantially lower failure rate (5.4% vs. 16%, RR 0.32 (0.14-0.76, p = 0.009)) with the KRF. The same review found no differences in the incidence of postpartum hemorrhage, anal sphincter injury (OASI), or extensive vaginal or cervical injury [36]. Meta-analysis was only possible for a small subset of outcomes, highlighting that further research is needed to study these outcomes.

A UK cohort study comparing 312 KRF with manual rotation and direct forceps delivery in 2017 reported a lower failure rate (11.5% vs 17.8%), shoulder dystocia higher rate (19.2% vs 10.6%; RR, 2.35, 1.23-4.47) and equivalent maternal and perinatal outcomes with the KRF [37].

Author, year of pubblication	Contest	Sample dimention	Findings
Wattar 2015	Systematic review of observational studies	5870 Rotational Forcipes	Rotational forceps has a lower rate of neonatal trauma and a lower failure rate than rotational vacuum extraction. There is no risk of postpartum hemorrhage, anal sphincter damage, extensive vaginal or cervical lacerations difference.
O'Brien 2017	Retrospective cohort	312 Rotational Forcipes	Higher success rate of forceps delivery, increased incidence of shoulder dystocia, but no neonatal injury. There are no differences about other maternal or neonatal outcomes.

Box 2: Rotational Forcipes Outcomes Versus Others Approach.

Forceps Delivery Outcomes

There is currently no specific study about operative vaginal delivery, although there is one under development and registered in the COMET database [38]. However, published main findings on maternity care models reflect prioritizing outcomes from the perspective of patients and clinicians [39].

Randomized trials comparing outcomes of forceps versus vacuum assisted delivery were evaluated in a Cochrane systematic review published in 2010 [40]. Two large observational studies comparing vaginal-assisted deliveries with intrapartum cesarean deliveries in Canada in the years 2003-2013 and 2004-2014 were analyzed [41,42]. A subgroup analysis of labors and births in the context of prolonged second stage of labor, depending on whether forceps or vacuum extractors were used, has been made. The primary outcomes in each study were the composite severe perinatal morbidity and mortality (e.g., seizures, assisted ventilation, severe birth trauma and perinatal death) and the composite severe maternal morbidity and mortality (e.g., severe postpartum hemorrhage, shock, sepsis, cardiac complications, acute renal failure and death) (see box 3).

Author, year of pubblication	Contest	Sample dimention	Findings
O'Mahony 2010	Cochrane collaboration	6597 (32 trials)	Forceps compared to vacuum cup can be associated with increased risk of perineal trauma and maternal pelvic floor dysfunction; lower failure rate; increased risk of damage to the newborn's face; reduction in the risk of retinal hemorrhage.
Muraca 2018	BC, Canada retrospective cohort 2003-2013	10.901	Forceps is associated with increased fetal morbidity and mortality and severe maternal morbidity compared to CS.
Muraca 2017	BC, Canada retrospective cohort 2004-2014	187.234	Forceps is associated with increased fetal morbidity and mortality and severe maternal morbidity compared to CS.
Murphy 2004	Bristol, UK Prospective cohort	393	Cesarean section is associated with an increased rate of postpartum hemorrhage, with an increase in NICU admissions and prolonged maternal hospitalization. Forceps is associated with an increased rate of neonatal trauma.

Box 3: Vaginal Operative Delivery with Forceps Outcomes

Maternal Complications of Operative Vaginal Birth

Perineal Trauma

Due to the nature of forceps, it is common to experience episiotomy (~90%), perineal tears (~20%) or obstetric anal sphincter injury (OASI (~10%)) during its use [5]. Although the significant heterogeneity between studies, there is no clear difference in the rate of episiotomies performed with forceps and with vacuum extraction, nor in the rate of perineal tears requiring suture or vulvar trauma.

Regardless of the use of episiotomy, forceps are associated with an increase of both third- and fourth-degree tears (10 studies - RR 1.89, 95% confidence interval 1.51-2.37), and vaginal trauma (8 studies - RR 2.48, 95% CI 1.59-3.87). One study evaluated the risk of incontinence of flatus and liquids following forceps or vacuum extraction, forceps was associated with a higher risk of this outcome (RR 1.77, 95% CI 1.19-2.62) [40].

Muraca et al., in their 10-year Canadian cohort study, reported overall risks of obstetric trauma (defined as any of severe perineal tears (third or fourth degree), cervical laceration, upper vaginal laceration, organ injury/ pelvic joint, pelvic hematoma, or extension of the uterine incision) following midpelvic forceps delivery compared with cesaren section [42]. Forceps use was still associated with an eightfold increase in the risk of obstetric trauma during a labor dystocia and with a fivefold increase in case of fetal distress.

A systematic review of studies comparing rotational forceps with rotational vacuum extraction identified no differences in the risk of significant perineal injury (extensive vaginal lacerations, cervical lacerations, or third- or fourth-degree tears) [36]. The overall rate of OASI from 16 studies was 5.6%. Another recent study about the outcomes of rotational forceps versus manual rotation followed by direct forceps application reported a respective OASI rates of 9.6% and 5.8%, but was not statistically significant (aRR 1.99, 0.90-4.39).

Episiotomy Role

Episiotomy during a forceps delivery is an accepted practice. There is moderate quality evidence that this reduce OASI risk. Ia study of over 130,000 births in the Dutch Perinatal Registry, the use of mediolateral episiotomy during both vacuum-assisted and forceps-assisted delivery was associated with a 5- to 10-fold reduction in the rate of OASI in primiparous and multiparous women [43]. The incidence of forceps-assisted births in primiparas was 3.4% with right mediolateral episiotomy and 26.7% without. The incidence in multiparous women was respectively of 2.6% and 14.2% [43].Some evidence also suggested that perineal protection could prevent these injuries. School training programs have been linked to a 48% OASI reduction in all vaginal deliveries in Norway after the introduction of a perineum protection training program for midwives and physicians [44].

A formal teaching and training session on performing forceps-assisted deliveries was organized for junior physicians and found to be associated with a 26% reduction in severe perineal laceration after forceps delivery in a US study out of 4279 deliveries [45].

Pelvic Floor Morbidity and Incontinence

A cohort study of 3763 women in the UK and New Zealand demonstrated that long-term (12 years) rates of stress urinary and urge incontinence were higher after forceps-assisted delivery than with cesarean: 19% vs 13% of women experiencing stress incontinence, 4.5% vs 3.0% with urge incontinence, and 13% vs 8.2% with both types, respectively [46]. Forceps delivery was also associated with a higher rate of pelvic organ prolapse than cesarean delivery (61% versus 5.9%, pelvic organ prolapses in any compartment). The same study reported that 5% of women who underwent forceps-assisted delivery did prolapse surgery compared with none in the caesarean delivery group [47].

Postpartum Hemorrhage

The evidence from the Cochrane review demonstrated no difference in maternal blood loss between forceps delivery and vacuum assisted delivery, although only two studies reported this finding, one of which had only 36 participants [40]. In the rotational forceps setting, a total rate of postpartum hemorrhage of 6.5% (range 4.2-9.9%) was reported by 16 studies, but there was no significant difference in comparison with forceps application (RR 1.16, 0.76-1.78). When a forceps delivery with a low station fetus is performed, observational evidence from 7046 (n= 6265 forceps and 781 cesarean) women in China suggested that the risk of minor postpartum hemorrhage is increased compared with cesarean section [48]. Similarly, a Canadian study of 1763 mid-pelvic forceps-assisted delivery attempts versus 2405 second-stage caesarean sections for dystocia reported 21% postpartum hemorrhage and 1% severe postpartum hemorrhage after forceps and 4.62% and 0.5% after cesarean section (RR 4.39, CI 3.8 - 5.1; RR 2.46, CI 1.43-4.25) [42].

Requirements for Analgesia

Trials from the Cochrane review comparing forceps and vacuum assisted births reported no difference in local analgesia requirements for the procedure itself, nor any difference in pain on fourth day. No significant results suggested that regional anesthesia was more likely to be used with forceps than vacuum extractor. General anesthesia has been reported more commonly with forceps than with vacuum extractors.

Adverse Psychological Effects

A 2012 English national survey of postnatal women (n = 5332) showed that negative psychological status and emotional trauma were more common with forceps than with any other mode of birth, with spontaneous vaginal delivery and caesarean section planned associated with the least number of psychological problems [49]. However, findings from the Norwegian Mother and Child cohort study (n = 55,814) found no association between birth mode and emotional distress levels up to six months postnatally [50]. This may reflect differences in the circumstances surrounding operative vaginal deliveries across the different study settings. In qualitative studies, women describe negative birth experiences when they were not involved in the decision to have a forceps or vacuum assisted delivery. Positive experiences, therefore, imply the cooperation and empowerment of women [51].

Further Deliveries

In a prospective cohort study of 393 UK women contacted three years after operative delivery, almost half of them wished to avoid a further pregnancy, half of whom due to the fear of childbirth [52]. There were no significant differences between forceps delivery and second-stage cesarean section (1.75, 0.58-5.25).

However, were much more likely to have a vaginal birth at their next birth women who underwent a mid-pelvic forceps surgery than whom did a second-stage cesarean section (80% versus 30%) [33].

Outcomes on Offspring

Neonatal Condition

A Cochrane review of randomized trials comparing vacuum and forceps-assisted births showed no difference in the risk of low Apgar scores, umbilical cord blood pH, neonatal hospitalization, or length of stay, as well as death or severe morbidity. However, the risk of facial injuries was five times more common with forceps compared to vacuum extraction [40]. A Canadian retrospective cohort study compared attempted forceps delivery (n = 4741) to cesarean section during the second stage of labor (n = 9300) in the context of prolonged labor and found a significantly increased risk of severe perinatal morbidity and mortality (1.1% vs 0.7%, AOR 1.81, 95% CI 1.24-2.64) in the case of attempted forceps delivery. Neonatal seizures assisted ventilation through endotracheal intubation, severe birth trauma (such as laceration and intracranial hemorrhage, skull fracture, severe central or peripheral nervous system injuries, long bone fractures, subaponeurotic hemorrhage and liver or spleen injury), stillbirth and neonatal death were observed [41]. However, there is a risk of selection bias since the cesarean section group likely involved women with fetuses at a higher station than the group who attempted forceps delivery.

In a subsequent Canadian study of over 10,000 births in the second stage of labor with dystocia, forceps delivery at the mid-pelvic level was associated with a doubling of severe perinatal morbidity and mortality compared to cesarean section (as a first-line approach), affecting 1.7% after forceps delivery and 0.83% after cesarean section (ARR 2.11, 1.46-3.07), with severe birth trauma affecting 0.29% and 0.96%, respectively (ARR 4.3, 2.31-8.11) [42]. No difference was found in the need for assisted endotracheal ventilation. When analyzing the subgroup of deliveries for fetal

distress, the increased risk of perinatal morbidity and mortality with attempted forceps delivery was not statistically significant, and there was no difference in 5-minute Apgar scores or respiratory distress, but a slight reduction in the need for endotracheal tube ventilation after attempted forceps delivery compared to cesarean section (1.13% and 1.08%, ARR 0.69, 0.49-0.97).

Eye Injuries

Ophthalmic injuries are a recognized complication of forceps-assisted births, suggesting rates of "minor external trauma" to the eye of 16% and "ophthalmic injuries" ranging from eyelid bruising to nerve injuries and corneal trauma of 0.2% [53,54].

Neurodevelopmental Outcomes

A Cochrane review of studies comparing forceps-assisted delivery with vacuum extraction showed no differences in neurodevelopmental outcomes at 5 years [40]. Similarly, a prospective cohort study in the UK comparing mid-pelvic forceps births with rotational forceps births and cesarean section found an increased incidence of traumatic injuries with forceps but no difference in neurodevelopmental outcomes at 5 years [55-57].

Rotational Forceps Injuries

A systematic review of observational studies comparing alternative approaches to birth in the context of malposition reported neonatal trauma in 7.5% (range 4.5-12.1%) and neonatal intensive care unit admission in 8.9% (range 6.0-13%) following the use of rotational forceps [36]. Neonatal jaundice was found in 19% (range 11-30%) following birth with rotational forceps. Shoulder dystocia occurred in 4.3% (range 3-6.2%). Adverse fetal outcomes after the application of rotational forceps include skull fracture (0.1% occurrence in the meta-analysis) and mortality (0.3%), but there is no clear evidence suggesting that these outcomes are more likely after the use of forceps compared to alternative options for rotational vaginal delivery.

Management of Failed/Abandoned Forceps Delivery

When the decision is made not to proceed with forceps-assisted delivery for safety reasons, delivery should be performed via cesarean section. At this stage of labor, the fetal head is likely deep in the pelvis and potentially engaged. Operators must be skilled in techniques to manage a deeply engaged fetal head as the time available to address the problem is limited to minutes, and complications for the mother and newborn can be significant. Randomized studies on which techniques to apply for managing a deeply engaged fetal head during cesarean section have been synthesized in a Cochrane review in 2016 [58].

Techniques used to disengage the fetal head from the maternal pelvis include routine combination of manual release from above (via uterotomy) with upward displacement of the fetal head from below (via the assistant's hand in the vagina). Relaxation of the uterine muscle can be achieved through the use of sublingual glyceryl trinitrate spray. Additional strategies to aid manual release include the use of a head-down tilt on the operating table. An alternative to these additional measures is performing a breech delivery before the fetus's feet or buttocks (inverse breech extraction). Evidence from the Cochrane review suggests that breech delivery compared to vaginal release is associated with less maternal bleeding, infection, and operative time, lower neonatal unit admission, and no difference in the risk of neonatal trauma [58]. Another technique used involves delivering the shoulders first, followed by the trunk, buttocks, limbs, and then the head. This technique, known as "Patwardhan," has only been the subject of small observational studies [59].

Recent developments in clinical practice include the use of a "fetal cushion" aimed at lifting the fetal head upward and detaching it from the maternal cervix, thereby interrupting the potential suction effect and simplifying the cesarean section. The inflatable device is designed to hold 180 ml of water, which is inserted once the maternal legs are straightened on the operating table [60,61].

A randomized study (n=240) on the use of the fetal cushion compared to usual practice in second-stage cesarean section demonstrated a significant reduction in delivery difficulty, shorter time from skin incision to neonatal birth (incision-to-delivery time), shorter operating times, smaller uterotomy extension, reduced blood transfusion requirement, and no difference in perinatal outcomes compared to routine practice.

Given the time pressure and potential complexity associated with cesarean section in the second stage following a failed attempt at assisted forceps delivery, it is essential for the healthcare team to be prepared and able to act swiftly to facilitate an immediate cesarean section once the decision is made. This requires a high level of communication between midwives, operating room staff, anesthesiologists, obstetricians and pediatric teams, as well as the availability of relevant equipment, medications and personnel if needed.

Postnatal Debriefing

All women who undergo attempted or actual forceps-assisted delivery should be informed postnatally to ensure they understand the context and indication for assisted delivery, any encountered complications, their recovery and potential consequences for future births. This is a valuable component of maternity care.

Forceps are a commonly used instrument for assisting vaginal delivery. Recognized interventions to reduce the likelihood of forceps-assisted delivery include individual support during labor and low-dose epidural anesthesia rather than high doses. Previous systematic reviews of randomized studies suggest that avoiding labor induction reduces the risk of forceps-assisted delivery, although more recent evidence has cast doubt on this. Most procedural aspects of forceps delivery are based on expert opinion rather than solid evidence. Accepted indications include prolonged labor, non-reassuring fetal status, and maternal medical conditions that benefit from a shortened second stage of labor.

The maternal and neonatal outcomes of forceps-assisted birth are reported in observational studies, and evidence from randomized trials is largely limited to comparisons between forceps and vacuum extraction. Forceps delivery increases the risk of maternal episiotomy, perineal lacerations, and anal incontinence compared to vacuum extraction. When specifically focusing on mid-pelvic forceps deliveries, observational studies suggest that severe maternal trauma is four times higher compared to second-stage cesarean section.

However, the rate of vaginal deliveries with forceps is higher than with vacuum extraction, and if second-stage cesarean section is avoided, women have a much higher likelihood of achieving a spontaneous vaginal delivery without complications in subsequent pregnancies.

The morbidity and mortality of offspring up to five years of age are similar when assisted with forceps or vacuum extraction.

Population-based studies in the United States and Canada suggest that second-stage cesarean section may be associated with a reduced risk of severe neonatal morbidity compared to attempted mid-pelvic forceps delivery. However, the absolute risk appears to be small, and a five-year follow-up from a prospective UK cohort showed no difference in neurological developmental outcomes. Observational evidence supports the use of low-forceps as a safer alternative to second-stage cesarean section, reducing the risk of perinatal morbidity, including hypoxic-ischemic encephalopathy. Counseling and informed consent regarding forceps-assisted birth are particularly important, and given the complexities involved, this should begin in the prenatal period and be discussed again during labor if the possibility of intervention arises. Forceps-assisted births can have traumatic psychological consequences, highlighting the importance of good communication skills and technical expertise during emergency deliveries.

Application Technique of The Forceps

This instrument consists of two branches, left and right, depending on the portion of the pelvis they are intended for. Each branch is composed of four parts: Spoon, Collar, Joint, and Handle. Since the branches of almost all forceps are crossed, the handle of the left branch corresponds to the operator's left hand, and the handle of the right hand corresponds to the right branch. The spoon that is to be applied to the part of the fetus to be extracted (i.e., the head) is mostly fenestrated, meaning it has two blades - metal parts that delimit the window - which join together anteriorly in a bite and posteriorly in a collar. The spoons have a curvature that adapts to that of the fetal part, hence called cephalic curvature. The collar, of varying length depending on the type of forceps, is in contact with the collar of the other branch when the instrument is assembled and continues into the joint.

The joint varies greatly among different forceps: in Simpson forceps, it is an interlocking joint, composed of two notches that fit together. In this type, the collars are mostly parallel and not convergent, reducing the compressive action of the branches on the fetal head. In Tarnier forceps, the joint is a screw thread, where the left branch has a pin that fits into a notch on the right branch, and then the pin is screwed to solidify the two branches. The joint is a fixed pin in Naegele forceps, meaning there is a pin in the left branch that cannot be screwed. In another forceps, Kjelland forceps, the joint is sliding, allowing the two branches to articulate at different levels, so the two spoons may not be in exact alignment. The handle of each branch is made of solid metal and has a fin, which in some forceps is located below the joint area (Simpson, Naegele and Kjelland forceps), while in others it is at the lower end (Tarnier and Piper forceps). Sometimes the handle is not smooth but has small lateral grooves for the fingers to grip or pull. Some forceps are also equipped with a traction device, which is generally applied at the collar level (as in Tarnier forceps) or at the joint level. This device serves to avoid direct traction on the branches (thus reducing compressive forces on the head) and instead allows the head to progress along the central axis of the pelvis.

Once assembled, the forceps show a cephalic curvature (determined by the shape of the spoons) and a pelvic curvature, determined by a certain angle between the spoons and the handles, so they adapt to the axis of the pelvis. This pelvic curvature varies in different forceps: it is pronounced in Naegele forceps, slightly marked in Piper forceps, and practically absent in Kjelland forceps. The overall dimensions of the forceps and the individual parts also vary among different types. The average weight ranges from 600-900 grams, the length is typically 35-40 cm, with one-third belonging to the spoons. The span, i.e., the maximum distance between the closed spoons, is 8 cm. The bites are spaced 0.5-1 cm apart, the spoons are 5 cm wide, and the fin rises from the horizontal plane by 9-10 cm (Figures n.1-2-3-4-5-6-7-8-9).

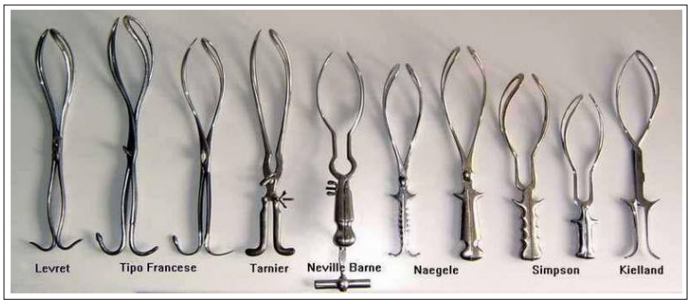

Figure N 1: Various Types of Forceps

Figure N 2: Interlocking Kielland Forceps

Figure N 3: Interlocking Naegele Forceps

Figure N 4: Simpson Forceps

Figure N 5: Smelie Forceps, Interlocking Joint

Figure N 6: Kielland Forceps, Interlocking and Sliding Articulation

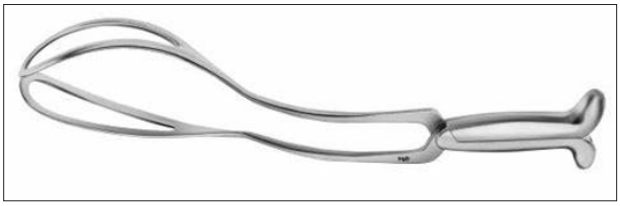

Figure N 7: Piper Forceps for Breech Presentations

Figure N 8: Tarnier Forceps

The pulling handle is applied directly to the shells.
The median screw serves to graduate the pressure on the fetal head.

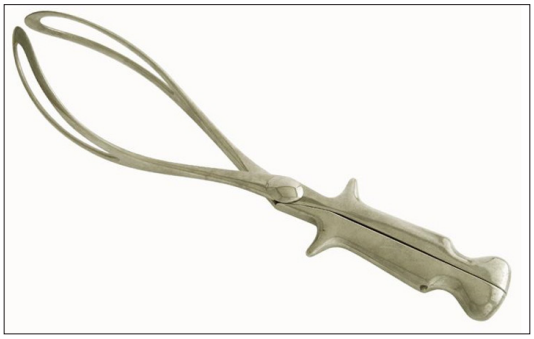

Figure N 9: Nagaele Forceps

The main action of the forceps is traction. The line of traction should correspond to the axis of the birth canal, and the force will be applied and directed differently depending on the position of the fetal head relative to the pelvis. The rotational action is also important: it should be exerted to make rotational movements of the head in the pelvis if they haven't already occurred. To exploit this function, it is necessary to keep in mind that the spoon-shaped ends of the forceps usually have a certain angle with the handles. Since the spoons need to "rotate in place", the handles must move in an arc. The compressive action exerted by the forceps on the fetal head is an inevitable effect and potentially harmful. During traction, small lateral movements can be applied to facilitate the passage of the larger diameter (or circumference) through the birth canal by a rocking motion, which is not accepted or recognized by all authors. It is important to note that mastery of the instrument, accurate diagnosis of the position and attitude of the head in the pelvis, and an understanding of the movements the head still needs to make for extraction are required.

The general technique for applying forceps involves a precise sequence of steps:
1. Selection of the branch to be introduced first
2. Introduction of the first guiding hand
3. Introduction of the first branch
4. Introduction of the second guiding hand
5. Introduction of the second branch
6. Articulation of the branches
7. Trial traction
8. Extraction of the head

(Figures N.10-11-12-13)

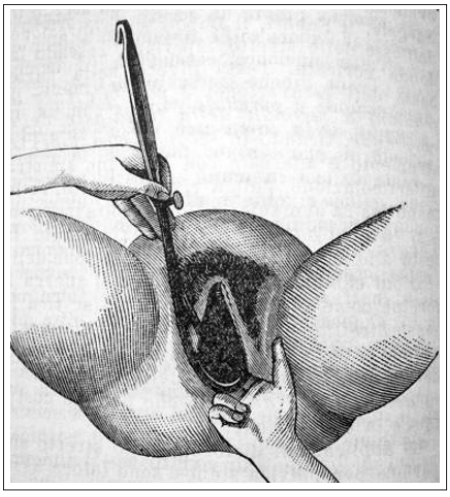

Figure N 10a: Application of The Left Branch of the Forceps

Figure n 10b: Left branch application (personal photo)

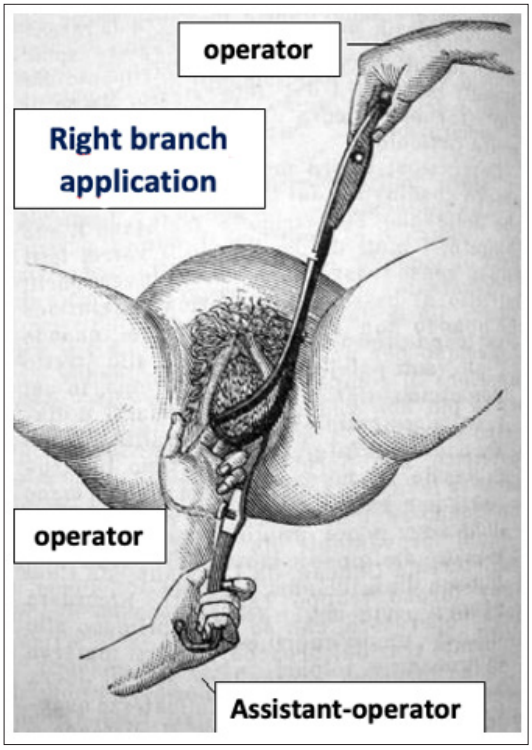

Figure n 11: Right branch application

Figure n 10c: Left branch application (personal photo)

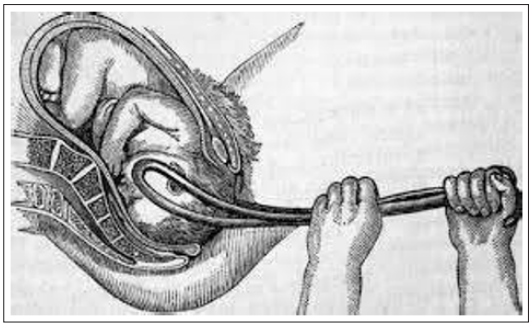

Figure n 12: Pajot's maneuver - extraction

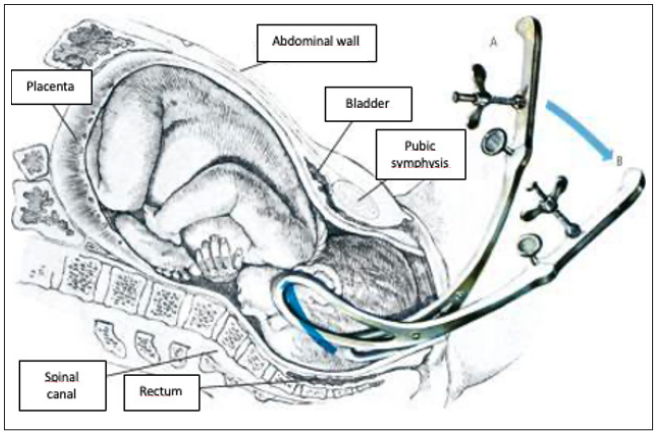

Figure n 13a, b, c, d, e, f: Correct direction of traction

Figure 13a: Nagaele forceps correctly applied (personal photo)

Figure 13b: Nagaele forceps correctly applied, and traction started (personal photo)

Figure 13c: Properly applied Nagaele forceps and traction (personal photo)

Figure 13d: Correctly applied Nagaele forceps, traction and episiotomy performed (personal photo)

Figure 13e: Correctly applied Nagaele forceps and upward traction (personal photo)

Figure 13f: Correctly applied Nagaele forceps, upward traction (personal photo)

Before starting the procedure, it is advisable to
a) Make an accurate diagnosis of the fetal position.
b) Ensure that the permissive conditions and prerequisites are met.
c) Verify the proper functioning of the forceps, especially the articulation.

To begin the maneuver, it is good practice to place the closed forceps just in front of the woman's genitals in the same position it will be in the pelvis. This clearly indicates the priority to be given to each branch and where each should be applied. Two principles must always be observed: the left branch should be grasped with the left hand and applied to the left half of the pelvis, guided by the right hand; the right branch should be grasped with the right hand and applied to the right half of the pelvis, guided by the left hand. The pelvic curvature should be systematically and logically oriented forward, towards the anterior pubic arch, more or less centralized, and towards the sacropubic direction or obliquely towards the ileopubic eminence-sacroiliac joint, depending on the case. The application of the forceps can be direct or indirect with respect to the pelvis, and the application of the cephalic curve (spoon handles) can be symmetric or asymmetric: in the former case, the biparietal diameter is grasped, while in the latter case, the fronto-occipital diameter or a diameter from the frontoparietal ridge on one side to the parieto-occipital ridge on the opposite side is grasped. It is evident that the ideal application for the fetus is the symmetric one, as it is less traumatic and allows for a better grip. Therefore, this application should be preferred even if it may be indirect or oblique with respect to the pelvis if the head is not sufficiently rotated yet.

In general, the first branch to be introduced is the left one, as it usually carries the pivot of the joint (fixed or mobile) and the lower wing of the interlocking joint type.

It is introduced into the pelvis, starting the movement almost at the level of the sacrum, positioning more posteriorly in asymmetric applications. However, there are cases where the right branch should be applied first, as it will be posterior in some oblique applications. This happens when the occiput is oriented towards the right ileopubic eminence, the left sacroiliac symphysis, and the right extreme of the transverse diameter of the pelvis. These three points constitute the "Jaulin triangle." In such cases, applying the right branch first, followed by the left branch, requires a "crossing" maneuver to articulate the two branches of the forceps (Figures n. 10-11-12-13).

The detailed steps for applying the forceps are as follows

1. Depending on the position of the head, the left branch will be positioned first in direct and symmetric applications and in direct and asymmetric applications when the occiput is aligned with the left ileopubic eminence (or the right sacroiliac symphysis or the left extreme of the transverse diameter). The right branch will be positioned first in cases where the occiput is oriented according to the Jaulin triangle.
2. Once the branch to be introduced first is chosen, it is grasped with the corresponding hand and inserted into the birth canal: right hand for the left branch, left hand for the right branch. It is usually necessary or advisable to enter the canal with the palm side of the four long fingers facing the fetal head, sliding them over the head. The fingers are inserted somewhat posteriorly, towards the sacral concavity. They will then be gradually moved upwards and forwards until they reach the site of application of the branch only when the branch itself is introduced. Only if the presenting part is very low, the introduction of two fingers, index and middle, may be sufficient.
3. On the guidance of the hand introduced into the birth canal, the chosen branch will be applied. The branch should be held like a pen, with a full hand or clenched fist as needed, according to preferences and habits. Initially, it should be oriented with the bite of the spoon towards the fork and the

handle in the direction of the inguinal arch on the opposite side. Subsequently, the branch is introduced while the fingers of the guiding hand are lifted and brought to the level of the point on the head where the branch will rest: to do this, it is necessary to make a large spiral movement with the handle, bringing the spoon from the sacral concavity to the end of the diameter where it should be placed. After ensuring with the guiding hand that the correct position relative to the pelvis and head has been reached, the handle of the branch is entrusted to an assistant, who must ensure its absolute immobility.

4. The introduction of the second guiding hand follows the previously described methods, with the fingers initially brought rather posteriorly in the immediate vicinity of the sacral concavity and then moved upwards and forwards until reaching the point of application of the second branch.
5. The application of the second branch is carried out using a technique similar to that described for the application of the first branch, naturally bringing the spoon (guided by the fingers already inserted into the birth canal and moving together with the spoon) to reach the opposite end of the diameter where the first branch has already reached.
6. Articulation of the two branches: if the left branch was introduced first and then the right branch (as in the case of symmetrical applications and left oblique positions), the articulation is done simply. If the two articulation points do not align, it means that the two spoons are not at an equal level in relation to the maternal pelvis and fetal head. One can try to move either branch to precisely align the two articulation points through small movements or retract one of the branches to repeat the application. If the right branch was applied first, the articulation points will be in opposition (the pivot above the notch), and the "crossing of the handles" must be performed to pass the branch that becomes superior under the other.
7. Once the branches are articulated, the correct application of the spoons according to the presentation, and especially the position of the head, is checked again. A trial traction is performed to ensure the effectiveness of the grip. The hands should be positioned at the articulation level as much as possible, both to reduce handle counterpressure on the spoons and to adapt the traction to the birth canal.
8. Extraction of the head. The tractions should be performed during uterine contractions, with suspension during the pause; they must be continuous and without jerks, and sometimes lateral movements may be unavoidable. The tractions themselves vary depending on the movements the head still needs to make in the birth canal until the presenting part reaches and surpasses the lower strait. At this point, traction should be exerted upwards to cause the head to undergo the movement of deflection and disengagement. When the head is about to pass through the vulvovaginal orifice, the branches are disarticulated. First, the secondly introduced branch is extracted, followed by the one introduced first. The perineum will be protected, and an episiotomy may be performed if necessary. Once the fetal head is delivered, subsequent assistance during the rest of the delivery proceeds as usual in a spontaneous birth. The integrity of the birth canal will be checked after the fetus is delivered, and once the placenta is expelled, any episiotomy and other lacerations will be sutured.

The fetal presentation can occur in various positions, which correspond to different maneuvers of insertion, application and traction of the forceps

a. Vertex presentation in public position: The head is generally in the lower part of the excavation or at the level of the lower strait. The application is symmetric for the fetus and direct for the mother. The branches' spoon part is positioned transversely across the pelvis and grips the head according to the biparietal diameter. The spoons should be oriented along a line that passes through the occiput and the mastoid region (with the windows surrounding the ears) and reaches the chin with the bite. The application of the branches starts with the left one and then the right one, and the articulation happens almost automatically. After the trial phase, the actual tractions will begin. The tractions are initially performed downwards and backwards, and as the head descends and the occiput passes the pubic symphysis, the tractions are exerted forwards and upwards to initiate the head's movement of deflection, resulting in disengagement.

b. Vertex presentation in occipito-left anterior position: The head is not yet rotated and is generally located between the middle and lower part of the pelvic excavation. It is advisable to have a symmetric application for the fetus and an indirect application relative to the pelvis. The fetal head is grasped by applying each branch along the occipito-mentonian direction and the spoon part follows the orientation of the right oblique. The introduction of the branches follows the same procedure: the left branch is applied first on the left parietal, followed by the right branch on the right parietal (with a wider movement). The traction maneuver allows for a rotational movement from left towards the subpubic angle of the head, enabling it to descend further into the pelvic cavity and bring the occiput forward. When the head reaches the lower strait with the occiput under the pubic symphysis, the situation will be similar to the one described earlier.

c. Vertex presentation in occipito-right anterior position: The head has the occiput corresponding to the right ileopubic eminence, and it requires the opposite application of the branches. The right branch should be applied first, adapting to the right parietal, while the left branch, to reach the left parietal, needs to describe a longer arc. As mentioned before, this is the case where the "uncrossing" of the handles needs to be practiced. Subsequently, the head must rotate from right to left until the occiput reaches the subpubic angle.

d. Vertex presentation in occipito-sacral position: This is a malposition due to a posterior right or left sacroiliac position. If the rotation is complete, the occiput is located in the sacral concavity, and the face is directed towards the pubic region. The head is almost always between the middle and lower part of the pelvic excavation. The application of the branches is symmetric and direct according to the transverse diameter of the mid-pelvis, following the classic order (with the left branch applied first and the right branch subsequently). In this way, they envelop the fetal head along the parietals from the occiput to the chin region. The pelvic curve faces the face of the fetus (not the back of the neck). Traction is initially exerted downward and posteriorly to allow the bregma and nose to slide below the pubic arch and should continue until the occiput reaches the perineum. By raising the handles of the forceps, traction is exerted upwards and forwards to allow the vertex to slip through the perineum, through a forced movement of head flexion. Once the occiput is freed and the nape reaches the fork, the head spontaneously deflects, leading to the expulsion of the face.

e. other presentations such as occipito-left transverse, occipito-right transverse, occipito-left posterior, occipito-right posterior, face and bregma are rare, and the use of forceps for these presentations is therefore outdated.

References

1. Information Services Division Scotland (2018) Births in Scottish hospitals. Year ending 31st.
2. The Health and Social care Information Centre (2013) Hospital episode statistics: NHS maternity statistics.
3. Black M, Mitchell E, Danielian P (2013) Instrumental vaginal deliveries; are midwives' safer practitioners? A retrospective cohort study. Acta Obstet Gynecol Scand 92: 1383-1387.
4. Murphy DJ, Koh DK (2007) Cohort study of the decision to delivery interval and neonatal outcome for emergency operative vaginal delivery. Am J Obstet Gynecol 196: 145. e1-7.
5. Royal College of Obstetricians and Gynaecologists (RCOG) (2018) Operative vaginal delivery. Green-top guideline N0.26 https://www.rcog.org.uk/guidance/browse-all-guidance/green-top-guidelines/.
6. Committee on Practice Bulletins-Obstetrics (2015) ACOG practice bulletin no. 154: operative vaginal delivery. Obstet Gynecol 126: e56-65.
7. Robertson PA, Laros Jr RK, Zhao RL (1990) Neonatal and maternal outcome in low-pelvic and midpelvic operative deliveries. Am J Obstet Gynecol 162: 1436e42. Discussion 1442-1444.
8. Hagadorn-Freathy AS, Yeomans ER, Hankins GD (1991) Validation of the 1988 ACOG forceps classification system. Obstet Gynecol 77: 356-360.
9. Cargill YM, MacKinnon CJ (2018) No. 148-guidelines for operative vaginal birth. J Obstet Gynaecol Can 40: e74-e80.
10. Christophe Vayssière, Gael Beucher, Olivier Dupuis, Olivia Feraud, Caroline Simon-Toulza, et al. (2011) Instrumental delivery: clinical practice guidelines from the French college of gynaecologists and obstetricians. Eur J Obstet Gynecol Reprod Biol 159: 43-48.
11. Bahl R, Stracham BK, Murphy DJ (2011) Operative vaginal delivery 26.
12. Jun Zhang, Helain J Landy, D Ware Branch, Ronald Burkman, Shoshana Haberman, et al. (2010) Contemporary patterns of spontaneous labor with normal neonatal outcomes. Obstet Gynecol 116: 1281-1287.
13. National Institute for Health and Care Excellence (2014) Intrapartum care for healthy women and babies.
14. International Federation of Gynecology and Obstetrics (2015) FIGO intrapartum fetal monitoring guidelines https://www.figo.org/news/available-view-figo-intrapartum-fetal-monitoring-guidelines-0015088.
15. National Institute for Health and Care Excellence (2017) Intrapartum fetal monitoring https://pathways.nice.org.uk/.
16. Towner D, Castro MA, Eby-Wilkens E, Gilbert WM (1999) Effect of mode of delivery in nulliparous women on neonatal intracranial injury. N Engl J Med 341: 1709-1714.
17. Bahl R, Van de Venne M, Macleod M, Strachan B, Murphy DJ (2013) Maternal and neonatal morbidity in relation to the instrument used for mid-cavity rotational operative vaginal delivery: a prospective cohort study. BJOG 120: 1526-1532.
18. Hodnett ED, Gates S, Hofmeyr GJ, Sakala C (2013) Continuous support for women during childbirth. Cochrane Database Syst Rev https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD003766.pub5/full.
19. Fraser WD, Marcoux S, Krauss I, Douglas J, Goulet C, et al. (2000) Multicenter, randomized, controlled trial of delayed pushing for nulliparous women in the second stage of labor with continuous epidural analgesia. the PEOPLE (pushing early or pushing late with epidural) study group. Am J Obstet Gynecol 182: 1165-1172.
20. Alison G Cahill, Sindhu K Srinivas, Alan T N Tita, Aaron B Caughey, Holly E Richter, et al. (2018) Effect of immediate vs delayed pushing on rates of spontaneous vaginal delivery among nulliparous women receiving neuraxial analgesia: a randomized clinical trial. J Am Med Assoc 320: 1444-1454.
21. Middleton P, Shepherd E, Crowther CA (2018) Induction of labour for improving birth outcomes for women at or beyond term. Cochrane Database Syst Rev 5: CD004945.
22. William A Grobman, Madeline M Rice, Uma M Reddy, Alan T N Tita, Robert M Silver, et al. (2018) Labor induction versus expectant management in low-risk nulliparous women. N Engl J Med 379: 513-523.
23. Michel Boulvain, Marie-Victoire Senat, Franck Perrotin, Norbert Winer, Gael Beucher, et al. (2015) Induction of labour versus expectant management for large-for-date fetuses: a randomised controlled trial. Lancet 385: 2600-2605.
24. Kate F Walker, George J Bugg, Marion Macpherson, Carol McCormick, Nicky Grace, et al. (2016) Randomized trial of labor induction in women 35 years of age or older. N Engl J Med 374: 813-822.
25. Epidural and Position Trial Collaborative Group (2017) Upright versus lying down position in second stage of labour in nulliparous women with low dose epidural: BUMPES randomised controlled trial. BMJ 359: j4471.
26. Debra Bick, Annette Briley, Peter Brocklehurst, Pollyanna Hardy, Edmund Juszczak, et al. (2017) A multicentre, randomised controlled trial of position during the late stages of labour in nulliparous women with an epidural: clinical effectiveness and an economic evaluation (BUMPES). Health Technol Assess 21: 1-176.
27. C Verhaeghe, E Parot-Schinkel, P E Bouet, S Madzou, F Biquard, et al. (2018) The impact ofmanual rotation of the occiput posterior position on spontaneous vaginal delivery rate: study protocol for a randomized clinical trial (RMOS). Trials 19: 109.
28. Hala Phipps, Jon A Hyett, Sabrina Kuah, John Pardey, Joanne Ludlow, et al. (2015) Persistent occiput posterior position - OUTcomes following manual rotation (POP-OUT): study protocol for a randomised controlled trial. Trials 16: 96. 9015.
29. Bahl R, Murphy DJ, Strachan B (2013) Decision-making in operative vaginal delivery: when to intervene, where to deliver and which instrument to use? Qualitative analysis of expert clinical practice. Eur J Obstet Gynecol Reprod Biol 170: 333-340.
30. General Medical Council (2018). Making decision about investigations and treatment https://www.gmc-uk.org/.
31. The Supreme Court (2015) Judgement: montgomery (appellant) vs Lanarkshire health board (respondent) (scotland) https://www.supremecourt.uk/cases/docs/uksc-2013-0136-judgment.pdf.
32. Royal College of Obstetricians and Gynaecologists (2010) Consent advice no. 11 Operative vaginal delivery.
33. Bahl R, Strachan B, Murphy DJ (2004) Outcome of subsequent pregnancy three years after previous operative delivery in the second stage of labour: cohort study. BMJ 328: 311.
34. Burke N, Field K, Mujahid F, Morrison JJ (2012) Use and safety of Kielland's forceps in current obstetric practice. Obstet Gynecol 120: 766-770.
35. Chiswick ML, James DK (1979) Kielland's forceps: association with neonatal morbidity and mortality. Br Med J 1: 7-9.
36. Al Wattar BH, Al Wattar B, Gallos I, Pirie AM (2015) Rotational vaginal delivery with Kielland's forceps: a systematic review and meta-analysis of effectiveness and safety outcomes. Curr Opin Obstet Gynecol 27: 438-444.
37. O'Brien S, Day F, Lenguerrand E, Cornthwaite K, Edwards

S, et al. (2017) Rotational forceps versus manual rotation and direct forceps: a retrospective cohort study. Eur J Obstet Gynecol Reprod Biol 212: 119-125.

38. The Comet Initiative (2019) COMET initiative http://www.comet-initiative.org/.
39. Devane D, Begley CM, Clarke M, Horey D, OBoyle C (2007) Evaluating maternity care: a core set of outcome measures. Birth 34: 164-172.
40. O'Mahony F, Hofmeyr GJ, Menon V (2010) Choice of instruments for assisted vaginal delivery. Cochrane Database Syst Rev 11: CD005455.
41. Giulia M Muraca, Yasser Sabr, Sarka Lisonkova, Amanda Skoll, Rollin Brant, et al. (2017) Perinatal and maternal morbidity and mortality after attempted operative vaginal delivery at midpelvic station. CMAJ (Can Med Assoc J) 189: E764-E772.
42. G M Muraca, Skoll A, Lisonkova S, Sabr Y, Brant R, et al. (2018) Perinatal and maternal morbidity, and mortality among term singletons following midcavity operative vaginal delivery versus caesarean delivery. BJOG 125: 693-702.
43. Jeroen van Bavel, Chantal W P M Hukkelhoven, Charlotte de Vries, Dimitri N M Papatsonis, Joey de Vogel, et al. (2018) The effectiveness of mediolateral episiotomy in preventing obstetric anal sphincter injuries during operative vaginal delivery: a ten-year analysis of a national registry. Int Urogynecol J 29: 407-413.
44. Laine K, Skjeldestad FE, Sandvik L, Staff AC (2012) Incidence of obstetric anal sphincter injuries after training to protect the perineum: cohort study. BMJ Open 2: e001649.
45. Gossett DR, Gilchrist-Scott D, Wayne DB, Gerber SE (2016) Simulation training for forceps-assisted vaginal delivery and rates of maternal perineal trauma. Obstet Gynecol 128: 429-435.
46. MacArthur C, Wilson D, Herbison P, Lancashire RJ, Hagen S, et al. (2016) Urinary incontinence persisting after childbirth: extent, delivery history, and effects in a 12-year longitudinal cohort study. BJOG 123: 1022-1029.
47. Volloyhaug I, Morkved S, Salvesen O, Salvesen KA (2015) Forceps delivery is associated with increased risk of pelvic organ prolapse and muscle trauma: a cross-sectional study 16-24 years after first delivery. Ultrasound Obstet Gynecol 46: 487-495.
48. Liu X, Landon M, Cheng W, Chen Y (2020) A comparison of maternal and neonatal outcomes with forceps delivery versus cesarean delivery. J Matern Fetal Neonatal Med 33: 307-313.
49. Rowlands IJ, Redshaw M (2012) Mode of birth and women's psychological and physical wellbeing in the postnatal period. BMC Pregnancy Childbirth 12: 138.
50. Adams SS, Eberhard-Gran M, Sandvik AR, Eskild A (2012) Mode of delivery and postpartum emotional distress: a cohort study of 55,814 women. BJOG 119: 298-305.
51. Sjodin M, Radestad I, Zwedberg S (2018) A qualitative study showing women's participation and empowerment in instrumental vaginal births. Women Birth 31: e185-e189.
52. Murphy DJ, Liebling RE (2003) Cohort study of maternal views on future mode of delivery following operative delivery in the second stage of labor. Am J Obstet Gynecol 188: 542-548.
53. McAnena L, O'Keefe M, Kirwan C, Murphy J (2015) Forceps delivery-related ophthalmic injuries: a case series. J Pediatr Ophthalmol Strabismus 52: 355-359.
54. Holden R, Morsman DG, Davidek GM, O'Connor GM, Coles EC, et al. (1992) External ocular trauma in instrumental and normal deliveries. Br J Obstet Gynaecol 99: 132-134.
55. Murphy DJ, Liebling RE, Verity L, Swingler R, Patel R (2001) Early maternal and neonatal morbidity associated with operative delivery in the second stage of labour: a cohort study. Lancet 358: 1203-1207.
56. Murphy DJ, Liebling RE, Patel R, Verity L, Swingler R (2003) Cohort study of operative delivery in the second stage of labour and standard of obstetric care. BJOG 110: 610-615.
57. Bahl R, Patel RR, Swingler R, Ellis N, Murphy DJ (2007) Neurodevelopmental outcome at 5 years after operative delivery in the second stage of labor: a cohort study. Am J Obstet Gynecol 197: 147.e1-6.
58. Waterfall H, Grivell RM, Dodd JM (2016) Techniques for assisting difficult delivery at caesarean section. Cochrane Database Syst Rev 1: CD004944.
59. Saha PK, Gulati R, Goel P, Tandon R, Huria A (2014) Second stage caesarean section: evaluation of patwardhan technique. J Clin Diagn Res 8: 93-95.
60. Seal SL, Dey A, Barman SC, Kamilya G, Mukherji J, et al. (2016) Randomized controlled trial of elevation of the fetal head with a fetal pillow during cesarean delivery at full cervical dilatation. Int J Gynaecol Obstet 133: 178-182.
61. Murphy DJ, Pope C, Frost J, Liebling RE (2003) Women's views on the impact of operative delivery in the second stage of labour: qualitative interview study. BMJ 327: 1132.