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Incidence changes in risk factors associated with the decreasing number of birth-related clavicle fractures in Finland: A nationwide retrospective birth cohort from 2004 to 2017

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Abstract

Background: A clavicle fracture is one of the most common birth injuries. The objective of this study was to examine whether the decreased incidence of birth-related clavicle fractures in Finland is because of temporal changes in their predisposing factors.

Methods: For this nationwide population-based study, we used the Finnish Medical Birth Register and the Care Register for Health Care databases. The study population included all singleton, live-born newborn born spontaneously or by vacuum-assisted delivery, in cephalic presentation ≥37^{+0} weeks of gestation. The incidences of clavicle fractures, pregnancy characteristics, and risk assessments for fracture were calculated and compared between two time periods: 2004–2010 and 2011–2017.

Results: A total of 629 457 newborn were born vaginally between 2004 and 2017. The clavicle fracture incidence decreased from 17.6/1000 to 6.2/1000 live births. Shoulder dystocia, diabetes, and birthweight ≥4000 g were the strongest predisposing factors. The incidence of birthweight ≥4000 g decreased, meanwhile type 1 diabetes and shoulder dystocia remained stable and gestational diabetes, type 2 diabetes, and maternal obesity increased in the later study period. The incidence of clavicle fractures without known predisposing factors declined. Simultaneously, the cesarean birth rate remained stable (13.2%–13.1%), although the rate of vacuum-assisted deliveries increased (8.5%–9.5%).

Discussion: The incidence of clavicle fractures decreased, even though the incidence of most risk factors remained stable or increased, and the cesarean birth rate remained stable. This decline may be related to the reduction of fracture incidence among deliveries without known risk factors, and the decrease in birthweight ≥4000 g.

KEYWORDS
birth injury, birthweight, clavicle fracture, risk factors, vaginal delivery

1 | INTRODUCTION

A clavicle fracture is one of the most common birth injuries occurring in newborns.[1,2] The prognosis is usually good, but a birth injury may be cause for concern in subsequent pregnancies and may influence attitudes toward a particular mode of delivery. Over the past two decades, the incidence of clavicle fracture has decreased in several countries, and now ranges from 0.5 to 11.2/1000 live births.[1–8]

Several predisposing factors with variable predictive values for clavicle fracture have been identified. The most common risk factor is increased birthweight. Indeed, it has been reported that approximately 20%–50% of injured newborns have a birthweight of over 4000 g.[5–10] A difficult birth has been found to be strongly associated with a clavicle fracture, although only 4% of injuries are associated with shoulder dystocia.[8] Other identified risk factors are advanced maternal age, short stature, obesity, malpresentation, type 1 diabetes (T1D), gestational diabetes, the use of oxytocin, and pain relief during labor.[4–8,11,12] However, often, there are only a few clinically important differences between injured and uninjured newborns.[5,11,13] The incidence of a clavicle fracture is also dependent on the mode of delivery, and it is mainly associated with spontaneous and instrumental vaginal delivery, even though some controversies exist.[4,5,7,8,11]

A previous study on birth injuries in Finland showed that the incidence of clavicle fractures in live-born newborns delivered in hospitals (including preterm newborns, multiple gestations, and breech deliveries) decreased by 70%, from 17.4/1000 live births in 1997 to 5.0/1000 live births in 2017.[2] Most of the clavicle fractures occurred after 37^{+0} weeks of gestation, and the incidence decreased among those born after 37^{+0} weeks of gestation.[2] However, the incidence of known clinical risk factors—such as gestational diabetes, advanced maternal age, and high body mass index (BMI)—have increased globally.[14–17] Here, we aimed to identify the pregnancy- and newborn-related predisposing factors for clavicle fracture, and to describe temporal changes in frequency and risk factors for injury between two time periods (2004–2010 and 2011–2017) in newborns born vaginally with cephalic presentations and gestational age $\geq 37^{+0}$ weeks. The study period was determined based on the changes in the Medical Birth Register (MBR). In the selected time ranges, the prenatal, delivery, and perinatal characteristics were more comprehensively registered than in previous years.

2 | METHODS

Birth data were obtained from the statutory, computer-based national MBR. The MBR is maintained by the National Institute for Health and Welfare and contains data on all live-born births and stillbirths with a birthweight ≥500 g or a gestational age of at least 22^{+0} weeks. The MBR includes demographic data, patient prenatal characteristics, delivery characteristics, perinatal outcomes, and infant diagnosis up to the age of 7 days or at discharge if earlier. The data are prospectively gathered during antenatal care and from the delivery units and supplemented by data from the Central Population Register and Causes-of-death registration at Statistics Finland. The validity of the MBR has been established; data quality and completeness are excellent.[18] All hospital visits with any birth-related clavicle fracture diagnosis (ICD-10 P13.4) recorded into the Care Register for Health Care during the first year after birth were included to increase data coverage beyond 7 days after birth. The Care Register for Health Care (a continuation of the previous Hospital Discharge Register) is a statutory, computer-based administrative register that contains patient characteristics, diagnoses, and operations performed during the hospital stay. The coverage and accuracy of the Care Register for Health Care have been evaluated as excellent.[19]

This study included all live-born newborns (n = 807 207) in Finland from January 1, 2004 to December 31, 2017. Preterm newborns, newborns born in breech presentation, multiple gestations, and newborns with osteochondrodysplasia (ICD-10 Q78.00-Q78.9) or spina bifida (ICD-10 Q05.0-Q05.9) were excluded from the study. Singleton newborns (n = 724 807) born in a cephalic presentation, $\geq 37^{+0}$ weeks of gestation in a hospital were included in a preliminary analysis. Forceps deliveries were excluded from further analysis because of a low number of procedures; cesarean births were also excluded because of the low incidence of clavicle fractures in this group (Figure 1).

The outcome variables in the present study were the number of birth-related clavicle fractures coded with the ICD-10 code P13.4 and variables associated with increased risk for fracture and their temporal alterations. ICD10-codes P14.0–14.3 were used for co-existing brachial plexus palsy. The pediatricians diagnosed a clavicle fracture based on the best clinical practice at the time. Numerous variables concerning demographics and delivery characteristics were analyzed (Table S1). Most of the variables were collected and

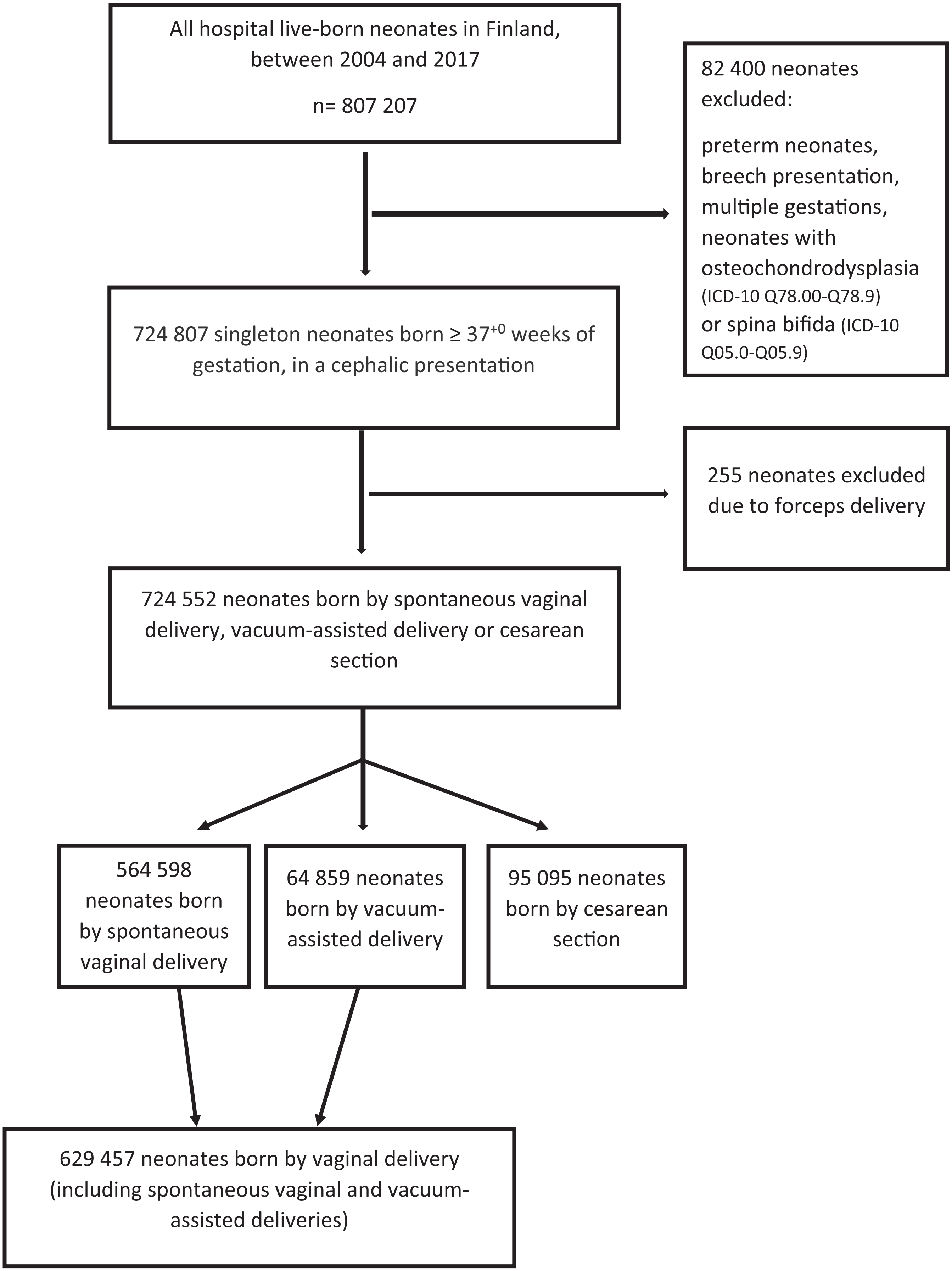

FIGURE 1 Study population

registered by a midwife. Some of the variables were formed from the Finnish implementation of the 10th Revision of International Statistical Classification of Diseases and Related Health Problems (ICD-10 codes) determined by an obstetrician/gynecologist. The variables included in further analyses are listed in Table 1. Spontaneous vaginal deliveries (SVDs) included spontaneous and induced deliveries as opposed to operative vaginal deliveries (vacuum-assisted deliveries). Large-for-gestational-age (LGA) diagnosis (ICD-10 O36.6) was used if LGA was suspected during antenatal care (estimated weight >2 SD based on ultrasound) or registered as a birth diagnosis (birthweight >2 SD or intervention was needed because of suspicion of birthweight >2 SD). Oxytocin was registered if it was used to either induce or augment labor. To evaluate the temporal change, the study was divided into two time periods—from 2004 to 2010 and from 2011 to 2017. Data concerning prepregnancy BMI were added after 2006, as a considerable number of values were missing in the years 2004 and 2005. Subsequently, part of the temporal change analyses started in 2006. For further analyses, some variables (age, height, BMI, weeks of gestation, and birthweight) first analyzed as a continuous variables were dichotomized.

2.1 | Statistical analysis

The incidences of birth-related clavicle fractures by a different mode of delivery were calculated. The incidences of demographics and delivery characteristics with each categorized variable were calculated, and the temporal change was analyzed by rate ratio with 95% confidence intervals, comparing the years 2011–2017 with 2004–2010. A rate ratio >1 indicated an increased incidence of the calculated variable in 2011–2017. The relative risk was used to estimate the probability of clavicle fracture between the two time periods, with 95% confidence intervals and a relative risk >1 indicating the enhanced impact of a variable on the clavicle fracture risk in the study period 2011–2017. Odds ratios and risk differences, with 95% confidence intervals, were used to evaluate the risk of a clavicle fracture. The odds ratio presents the odds that clavicle fracture will occur within a given exposure group versus an unexposed group; the risk difference represents the difference between the risk for a clavicle fracture in an exposed group versus an unexposed group. The difference in fracture incidence with the most clinically important variables was calculated by comparing the years 2011–2017 with 2006–2010 (incidence rate ratio [IRR], with 95% confidence intervals). Shoulder dystocia, T1D, birthweight ≥4000 g, BMI ≥ 30 kg/m^2 (obese), and gestational diabetes were included in the analysis and referred to as the main predisposing factors. They were chosen based on the risk for clavicle fracture, the temporal change of variables, and the unambiguousness of the variables' registration. Furthermore, birthweight ≥4500 g, birthweight ≥5000 g, labor induction, and gestational age ≥41^{+0} were included. The inclusion of these variables was based on the high risk for clavicle fracture associated with elevated birthweight, increasing trend of labor inductions, the decreasing incidence of labor after 41 gestational weeks, and clinical interest in evaluating the influence of the timing of the delivery on fracture incidence. Cluster-type analysis of clavicle fracture incidences with an increasing number of variables was done to explore the reduced incidence of clavicle fracture. Shoulder dystocia and T1D were excluded from these analyses because of their estimated modest impact on the declining trend of fractures because of their low incidences. Logistic regression analysis was used to assess the effect of the primary outcomes on the clavicle fracture risk and to construct risk estimation curves. Statistical analyses were performed using R 4.0.0. Only pseudonymized data were used in the study.

2.2 | Missing data and sensitivity analysis

The proportion of overall missing data was low (<1%), except for length 1.7% and BMI 4.3%. Thus, any methods for managing missing values were not applied. As the MBR contains all births in Finland, the study population covered all live births with the cephalic presentation, born beyond 37 gestational weeks during the study period. Therefore, the risk for selection bias was estimated to be low (Figure 1).

3 | RESULTS

The final study population included 629 457 newborns born in cephalic presentation, ≥37^{+0} weeks of gestation, spontaneously or by vacuum extraction (Figure 1). The total incidence of clavicle fracture was 10.4/1000 live births (n = 6577) including all vaginal deliveries, 9.2/1000 live births in SVD (n = 5175), and 21.6/1000 live births in vacuum-assisted deliveries (n = 1402). The clavicle fracture incidence in SVD decreased by 66% from 16.4/1000 live births (n = 671) in 2004 to 5.5/1000 live births (n = 190) in 2017, and by 61% in vacuum-assisted delivery from 31.1/1000 live births (n = 116) to 12.1/1000 live births (n = 54), respectively. In addition, 44 fractures were recorded after cesarean birth (incidence 0.46/1000 live births) during the whole study period. The 66% of fractures among the cesarean group were after unplanned cesarean births. Since injuries after cesarean remained infrequent and stable, they were excluded from the

TABLE 1 Maternal demographics, delivery characteristics, associated risk for clavicle fracture and temporal changes among singleton term vaginal deliveries with newborns born in cephalic presentation, Finland, 2004–2017

Maternal and delivery characteristics	2004–2010 (n = 321 691) Frequency (%)[a]	2011–2017 (n = 307 766) Frequency (%)[a]	*P*-value	Rate ratio (95% CI)	Relative risk (95% CI)	Odds ratio (95% CI)	Risk difference (95% CI)
Shoulder dystocia	1120 (0.3)	1079 (0.4)	0.87	1.01 (0.93, 1.09)	0.87 (0.71, 1.07)	15.9 (14.1, 18)	12.9 (11.5, 14.4)
Type 1 diabetes	711 (0.2)	687 (0.2)	0.85	1.01 (0.91, 1.12)	0.71 (0.43, 1.15)	4.58 (3.56, 5.89)	3.5 (2.6, 4.8)
Birthweight ≥4000 (g)	58 170 (18.1)	53 670 (17.4)	<0.001	0.96 (0.95, 0.98)	0.59 (0.55, 0.63)	3.89 (3.7, 4.08)	2.0 (1.9, 2.1)
Birthweight ≥4500 (g)	8235 (2.6)	7024 (2.3)	<0.001	0.89 (0.86, 0.92)	0.62 (0.53, 0.72)	4.85 (4.47, 5.25)	3.52 (3.21, 3.86)
Birthweight ≥5000 (g)	537 (0.2)	412 (0.1)	<0.001	0.8 (0.71, 0.91)	0.67 (0.41, 1.08)	7.38 (5.76, 9.45)	6.1 (4.7, 8.0)
Large-for-gestational-age	3632 (1.1)	4758 (1.5)	<0.001	1.37 (1.31, 1.43)	0.6 (0.48, 0.76)	3.45 (3.06, 3.89)	2.4 (2.0, 2,8)
Type 2 diabetes	186 (0.06)	371 (0.1)	<0.001	2.09 (1.75, 2.49)	0.6 (0.18, 1.95)	1.91 (1.05, 3.47)	0.9 (0.6, 2.5)
Use of oxytocin	134 581 (41.8)	149 146 (48.5)	<0.001	1.16 (1.15, 1.17)	0.56 (0.52, 0.6)	1.55 (1.47, 1.63)	0.4 (0.4, 0.5)
BMI ≥30 (kg/m^2)[b]	29 391 (12.7)	41 082 (13.3)	<0.001	1.05 (1.04, 1.07)	0.6 (0.53, 0.68)	1.52 (1.42, 1.63)	0.5 (0.4, 0.6)
Insulin treatment[c]	5435 (1.7)	4778 (1.6)	<0.001	0.92 (0.88, 0.96)	0.85 (0.62, 1.16)	1.49 (1.27, 1.75)	0.5 (0.3, 0.8)
Gestational diabetes	32 128 (10)	46 825 (15.2)	<0.001	1.52 (1.50, 1.55)	0.52 (0.46, 0.58)	1.36 (1.27, 1.45)	0.4 (0.3, 0.4)
Induction of labor	54 904 (17.1)	70 743 (22.3)	<0.001	1.35 (1.33, 1.36)	0.5 (0.46, 0.55)	1.35 (1.28, 1.43)	0.3 (0.2, 0.4)
Gestational age ≥ 41^{+0} (weeks)	84 525 (26.3)	77 598 (25.2)	<0.001	0.96 (0.95, 0.97)	0.56 (0.51, 0.61)	1.31 (1.24, 1.38)	0.3 (0.2, 0.4)
Paracervical and/or pudendal block	67 377 (20.9)	80 656 (26.2)	<0.001	1.25 (1.24, 1.26)	0.59 (0.54, 0.65)	1.2 (1.13, 1.27)	0.2 (0.1, 0.3)
Epidural and/or spinal anesthesia	178 799 (55.6)	201 394 (65.4)	<0.001	1.18 (1.17, 1.19)	0.6 (0.56, 0.63)	1.18 (1.23, 1.24)	0.2 (0.1, 0.2)
Multipara	193 717 (60.2)	188 717 (61.3)	<0.001	1.02 (1.01, 1.03)	0.61 (0.56, 0.66)	0.99 (0.95, 1.05)	0 (−0.1, 0.01)
Age ≥ 30 (years)	153 197 (47.6)	160 069 (52)	<0.001	1.09 (1.09, 1.10)	0.54 (0.50, 0.58)	0.95 (0.91, 0.10)	−0.1 (−0.1, 0)
Height ≥ 165 (cm)	184 443 (59)	176 127 (57.4)	0.57	1.00 (0.99, 1.01)	0.56 (0.53, 0.6)	0.84 (0.80, 0.89)	−0.2 (−0.2, −0.1)
Spontaneous vaginal delivery	290 357 (90.3)	274 241 (89.1)	<0.001	0.99 (0.98, 0.99)			
Vacuum-assisted delivery	31 334 (9.7)	33 525 (10.9)	<0.001	1.12 (1.10, 1.14)	0.62 (0.56, 0.69)	2.39 (2.25, 2.54)	1.3 (1.1, 1.4)
Vacuum-assisted delivery							
Prolonged II stage of labor[d]	7634 (24.4)	8515 (25.4)	0.008	1.04 (1.01, 1.08)	0.68 (0.56, 0.83)	1.3 (1.16, 1.46)	0.6 (0.3, 0.9)
Maternal distress[d]	2558 (8.2)	3059 (9.1)	<0.001	1.12 (1.06, 1.18)	0.53 (0.37, 0.75)	1.05 (0.87, 1.26)	0.1 (−0.3, 0.6)
Asphyxia or fetal distress[d]	14 165 (45.2)	17 078 (50.9)	<0.001	1.13 (1.10, 1.15)	0.67 (0.57, 0.80)	0.66 (0.59, 0.74)	−0.9 (−1.2, −0.6)
Malpresentation[d]	2496 (8)	3769 (11.2)	<0.001	1.41 (1.34, 1.49)	0.64 (0.38, 1.08)	0.38 (0.29, 0.49)	−1.4 (−1.7, −1.1)

Note: *P*-value calculated from Incidence rate ratio (IRR), using Chi-square test. Rate ratio comparing variables' incidences between periods 2011 and 2017 versus 2004 and 2010. Rate ratio > 1 meaning an increased incidence of the calculated variable in 2011–2017 compared with 2004–2010. Relative risk comparing risk difference between 2011 and 2017 versus 2004 and 2010. Relative risk > meaning the increased probability of clavicle fracture with exposure in 2011–2017 versus 2004–2010. Odds ratio represents the odds that clavicle fracture will occur within a given exposure versus an unexposed group. Risk difference represents the difference between the risk for a clavicle fracture in the exposed group versus the unexposed group (*100).

Abbreviation: 95% CI, 95% confidence interval.

[a]Frequency of variable and a percentage of total frequency.

[b]Since 2006.

[c]Insulin treatment started during pregnancy.

[d]Variables concerning only vacuum-assisted deliveries.

final study population and subsequent analysis. The overall cesarean birth rate remained stable at 13.2% from 2004 to 2010 and 13.1% from 2011 to 2017, whereas the vacuum-assisted delivery rate increased from 8.5% to 9.5% during the same time period. The annual clavicle fracture incidences with different delivery modes are presented in Figure 2. In addition to clavicle fracture, 330 newborns also had a brachial plexus injury (incidence 0.5/1000). The coexistence of these two injuries was rarer in the latter study period (2004–2010 incidence 0.7/1000, 2011–2017 incidence 0.3/1000). Fifty-nine newborns had clavicle fracture, brachial plexus injury, and shoulder dystocia.

Maternal demographics and delivery characteristics in vaginal deliveries are shown in Table 1. The most notable changes were an increase in the incidence of type 2 diabetes (T2D), gestational diabetes, and induction of labor. In addition, the incidence of LGA, pain relief during labor, oxytocin use, and obesity increased, whereas the incidence of birthweight ≥4000 g and delivery ≥41^{+0} gestational weeks decreased. Mean birthweight, mean gestational age, and the incidences of T1D and shoulder dystocia remained stable. When vacuum-assisted deliveries were considered separately, the incidence of malpresentation increased most, and approximately half of the procedures were performed because of asphyxia or fetal distress during the latter study period. The incidence of the most important clinical variables in different delivery modes between 2004–2010 and 2011–2017 are shown in Table S2. The rate ratios of risk factors were comparable among cesarean births, SVDs, and vacuum-assisted deliveries during the study periods.

Shoulder dystocia, T1D, and elevated birthweight were associated with the highest risk for clavicle fracture based on odds ratios and risk differences (Table 1). The impact of variables on the risk for clavicle fracture was lower between 2011 and 2017 than between 2004 and 2010, except in birthweight ≥5000 g, T1D and T2D, insulin treatment started during pregnancy, and shoulder dystocia of which the likelihood of fracture remained unchanged during the study period (Table 1, relative risk).

The fracture risk was higher in vacuum-assisted deliveries compared with SVDs, and it was highest if vacuum-assisted delivery was required because of a prolonged second stage of labor. Furthermore, the risk for clavicle fracture increased with increasing birthweight. For example, the probability of clavicle fracture in newborns born by vacuum-assisted delivery was 1.6% (95% CI 1.5, 1.7) with a birthweight of 3500 g, 3.2% (95% CI 3.0, 3.4) with a birthweight of 4000 g, and 6.4% (95% CI 5.8, 6.9) with a birthweight of 4500 g (Figure 3). The impact of birthweight was highlighted in women with T1D; in vacuum-assisted deliveries, the probability of injury with a birthweight of 3500 and 4000 g was 5.0% (95% CI 3.1, 8.0) and 9.7% (95% CI 6.1, 15.2), respectively. The relationship among birthweight, mode of vaginal delivery, and probability of injury in the whole study population and patients with T1D are presented in Figure 3.

The proportion of clavicle fractures with a risk factor for all clavicle fractures (fracture incidence with different variables/1000 fractures) was compared between the two study periods (Table 2). Only 1.1% of deliveries with clavicle fractures were associated with T1D and 5.0% with shoulder dystocia. Meanwhile, 44.9% of injured newborns had a birthweight of ≥4000 g, thus making high birthweight the most frequent risk factor. In total, 39.7% of deliveries with clavicle fractures were not related to any of the main predisposing factors (shoulder dystocia, T1D, birthweight ≥4000 g, BMI ≥ 30, kg/m^2, or gestational diabetes). A fracture incidence without any of the clinically important risk factors (also including gestational age ≥ 41^{+0} weeks and labor induction) was lower in 2011–2017 than in 2006–2010. Furthermore, fractures were more often associated with shoulder dystocia, gestational diabetes, and induced delivery during 2011–2017 (Table 2). Based on the cluster-type analysis, a decrease in fracture incidence without any of the risk factors was observed in 2011–2017, IRR 0.89 (95% CI 0.80, 0.99). Otherwise, no clear trend in changes in the associated factors was seen. The increased rate of fractures along with the four risk factors could be explained by sporadic fluctuation (Table 2).

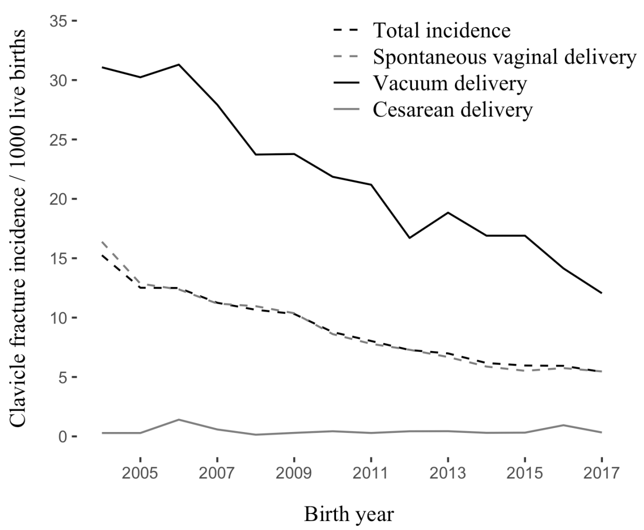

FIGURE 2 Clavicle fracture incidence by mode of delivery among term singleton births with newborn born in cephalic presentation, Finland, 2004–2017

4 | DISCUSSION

In Finland, the incidence of birth-related clavicle fractures in newborns born vaginally decreased by more than

60% between 2004 and 2017, despite the increased incidence of most risk factors in this study population, and the stable cesarean birth rate. Shoulder dystocia, high birthweight, and T1D had the strongest association with the injury. Low-risk patients, without any notable risk factors, accounted for a quarter of the fractures in this study. The incidence of clavicle fractures significantly decreased in these low-risk pregnancies. Furthermore, the decreased injury incidence may be related to the increase in the general incidence of labor induction accompanied by the decrease of high birthweight newborns.

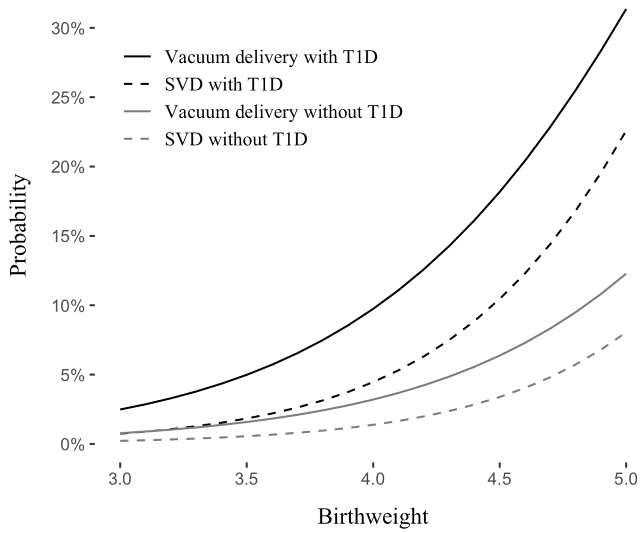

FIGURE 3 The probability of clavicle fracture in relationship to birthweight, mode of vaginal delivery, and type 1 diabetes (T1D)

4.1 | Strengths and limitations

The strengths of the present study are the statutory Finnish MBR and the Care Register for Health Care with national coverage and a long study period. The precision and completeness of the data have been reported to be high.[18,19] The large sample size enabled us to investigate a relatively rare outcome such as clavicle fracture. Considering Finland's stable and low cesarean rate, this study contributes knowledge on birth-related clavicle fractures in vaginal deliveries. A limitation of the study was that we were unable to analyze deliveries in more

TABLE 2 Birth-related clavicle fractures with different risk factors in vaginal deliveries, 2006–2010 and 2011–2017

Risk factors	2006–2010 (n = 2831) Frequency[a] (incidence/1000)	2011–2017 (n = 2312) Frequency[a] (incidence/1000)	*P*-value	IRR (95% CI)[b]
Shoulder dystocia (A)	118 (41.7)	139 (60.1)	0.003	1.44 (1.13, 1.84)
Type 1 diabetes (B)	31 (11)	26 (11.2)	0.92	1.03 (0.61, 1.73)
Birthweight ≥4000 (g) (C)	1263 (446.1)	1044 (451.6)	0.77	1.01 (0.93, 1.10)
Birthweight ≥4500	295 (104.2)	236 (102.1)	0.81	0.98 (0.83, 1.16)
Birthweight ≥5000	29 (10.2)	23 (9.95)	0.91	0.97 (0.56, 1.68)
Gestational diabetes (D)	403 (142.4)	458 (198.1)	<0.001	1.39 (1.22, 1.59)
BMI ≥30 (kg/m^2) (E)	518 (183)	434 (187.7)	0.69	1.03 (0.90, 1.17)
Gestational age ≥ 41^{+0} (weeks) (F)	913 (332.5)	694 (300.2)	0.15	0.93 (0.84, 1.03)
Induction of labor (G)	670 (236.7)	650 (281.1)	0.002	1.19 (1.07, 1.32)
Fracture without A-E[c]	1161 (410.1)	883 (381.9)	0.11	0.93 (0.85, 1.02)
Fracture without A-G	759 (268.1)	546 (236.2)	0.024	0.88 (0.79, 0.98)
Number of any of the risk factors (C-G)				
0 risk factor	779 (275.2)	564 (243.9)	0.029	0.89 (0.80, 0.99)
1 risk factor	914 (322.9)	746 (322.7)	0.99	1.0 (0.91, 1.10)
2 risk factors	676 (238.8)	593 (256.5)	0.2	1.07 (0.96, 1.20)
3 risk factors	362 (127.9)	297 (128.5)	0.95	1.01 (0.86, 1.17)
4 risk factors	85 (30)	103 (44.6)	0.007	1.48 (1.11, 1.98)
5 risk factors	15 (5.3)	9 (3.9)	0.46	0.73 (0.32, 1.68)

Note: *P*-value calculated from Incidence rate ratio (IRR), using Chi-square test.

Abbreviation: 95% CI: 95% confidence interval.

[a]Frequency of clavicle fractures and incidence/1000 fractures.

[b]IRR; Incidence rate ratio comparing clavicle fracture incidence between 2011 and 2017 versus 2006 and 2010.

[c]Referred as the main predisposing factors in the Results and Discussion.

detail because of the retrospective nature of the study and the restrictions on data use. For instance, the data on the exact duration of labor could not be used because of the imprecision of the coding, and the experience of health care professionals could not be evaluated. Furthermore, the diagnostic criteria for gestational diabetes changed during the study period,[15] and we cannot rule out the impact of some variation in diagnosing practices. Thus, for example, the impact of LGA diagnosis should be evaluated with caution. The large sample size and our focus on the most accurately collected data reduce potential biases.

4.2 | Interpretation

A clavicle fracture was rare in all delivery modes. Indeed, it was diagnosed in only 2.2% of vacuum-assisted deliveries and 0.9% of SVDs. The total incidence of clavicle fracture in newborns born vaginally is comparable to that reported in other studies.[5,6,10,20] Clinically, high birthweight was the most important risk factor and was involved in 45% of fractures throughout the study period. The relevance of increased birthweight is explicitly visualized in a regression curve (Figure 3). Elevated birthweight has also been recognized as a risk factor for clavicle fracture in other studies.[5,7–10] In addition, high birthweight is an important feature linked to many of the observed risk factors, such as pre-pregnancy obesity, diabetes, induction of labor, vacuum-assisted delivery, and shoulder dystocia.[12,14,21–27] Furthermore, high birthweight may increase the likelihood of serious co-existing injury, such as brachial plexus injury, along with clavicle fracture.[27] The incidence of birthweight ≥4000 g decreased across the study population, which may have had an impact on our finding of decreased incidence of clavicle fractures.

Global trends in increasing rates of obesity, gestational diabetes, T2D, and labor induction were also seen in this study.[14,17,28] Nonetheless, even as the incidence of gestational diabetes and T2D increased, the rate of newborns with birthweight ≥4000 g decreased. Further, the increased use of oxytocin, pain relief during labor, and LGA diagnosis may mark a change in antenatal and obstetric practices when caring for people with pregnancies deemed high-risk. Cross-culturally, clinical guidelines for labor induction vary substantially.[28–30] The increased incidence of high-risk pregnancies may partly explain the increased induction rate, and the decreased incidence of prolonged pregnancies and high birthweight. Moreover, the increased induction rate could partly explain the finding of decreased impact of most risk factors on clavicle fractures in the latter study period, especially since the cesarean rate and the incidence of birthweight ≥4000 g among newborns born by cesarean, remained unchanged (Table S2).

The incidence of clavicle fractures decreased by nearly two-thirds in vacuum-assisted deliveries, despite the increased rate of operative vaginal deliveries. During the latter study period, approximately 60% of vacuum deliveries were performed because of maternal distress or suspected fetal asphyxia or distress, and procedures related to these indications increased. This may reflect a lower threshold for intervention and could concurrently increase the rate of relatively easy—low or outlet station—vacuum deliveries. In addition, the technical skills needed to perform vacuum-assisted delivery may have improved. The increased risk for clavicle fractures among vacuum-assisted deliveries was associated with a prolonged second stage of labor, possibly indicating labor dystocia. Nevertheless, almost 80% of clavicle fractures were diagnosed after SVDs, and thus the changes in fracture incidence in vacuum-assisted deliveries have only had a modest effect on the total clavicle fracture incidence.

Clavicle fracture has a strong association with shoulder dystocia and T1D. The risk for fracture with T1D was related to increasing birthweight and was intensified if vacuum-assisted delivery was needed. A similar association with birthweight has been reported by Persson et al.[31] The incidence of shoulder dystocia and T1D increased or remained unchanged in the latter study period in cases with clavicle fracture. Although T1D and shoulder dystocia were essential risk factors, they could not explain the declining trend of clavicle fractures based on their low and stable incidences.

Numerous variables, such as obesity, gestational diabetes, induction of labor, and gestational age of $\geq 41^{+0}$ weeks, were associated with a mildly increased risk for injury. According to the results of this study and from a practical point of view, the influence of these variables on fracture risk is probably modest and at least partly because of birthweight and the large sample size. Even though the incidence of many associated factors increased over time, the risk factors did not accumulate to result in deliveries with a fracture. This discrepancy may be related to the minor impact of single risk factors on the absolute fracture risk.

The centralization of maternal hospitals, increasing interest in quality of care and patient safety issues, and the onset of simulation-based and hands-on training for shoulder dystocia during the latter study period may partly have influenced the clavicle fracture incidence.[32–35] In addition to the deliveries with major risk factors, a clavicle fracture may occur with few or nonexistent prior risk factors during regular SVD. These low-risk patients, without any notable risk factors, accounted for a quarter of the fractures in this study. The phenomenon of fracture incidents after regular delivery without risk factors has also been recognized by others.[5,8,11] According to our findings, the incidence of clavicle fractures significantly decreased in these low-risk pregnancies. The reasons for this decline remain, however, unclear and require further research.

Approximately 45% of the newborns with clavicle fracture had a birthweight ≥4000 g, thus the prevention of high birthweight might appear to be a tempting solution to reduce fracture incidence. However, the probability of fracture in deliveries with a birthweight of approximately 4000 g (without T1D) was low, and the prediction of birthweight or LGA-newborn by ultrasound or clinical measures is unreliable.[24,36] Moreover, there is no clear consensus on management with suspected macrosomia or whether labor induction can reduce the birth fracture risk.[24,27–29,37,38] As a substantial number of injuries were not related to known risk factors, the fundamental reason for the decline in the incidence of clavicle fractures remains unclear.

5 | CONCLUSION

The incidence of clavicle fractures decreased by two-thirds between 2004 and 2017, despite an increasing incidence of pregnancies deemed at risk. This decreased incidence may be a consequence of a decline of injuries in a group of women without risk factors and a decrease in the incidence of high birthweight newborns.

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DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICAL APPROVAL

This study was approved by the Ethics Committee of Tampere University Hospital (reference number R17069) and by the National Institute for Health and Welfare (reference number THL/1659/5.05.00/2017).

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SUPPORTING INFORMATION

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

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