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Nasogastric bridles are associated with improved tube-related outcomes in children

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Abstract

Objective: To compare tube-related outcomes in children with standard tape vs nasal bridle securement of nasogastric tubes (NGTs).

Study Design: This was a single-center, retrospective, correlational study of outcomes from the time of NGT placement until full oral feeds or durable-tube placement. Outcomes of interest included NGT dislodgments, length of stay, emergency department (ED) encounters, radiographic exposures, and adverse skin outcomes. Negative binomial regression and logistic regression were used to analyze differences between groups.

Results: Five hundred eighty-two children had NGTs secured traditionally (43% female; age at therapy initiation of 2.6 months [SD 8.1]), and 173 received nasal bridles (55.5% female; age at therapy initiation of 8.4 months [SD 11.8]). Children with bridled NGTs were 16.67 times less likely to experience one or more dislodgments (odds ratio [OR] = 0.06; 95% CI, 0.04–0.09); 2.5 times less likely to have one more ED visit (OR = 0.4; 95% CI, 0.19–0.82), and 4.76 times less likely to require one more radiographic exposure (OR = 0.21; 95% CI, 0.14–0.33) than unbridled children (all *P* values < 0.02). The mean initial hospital length of stay was 28 and 54 days in the bridled-NGT and standard-care groups, respectively (*P* < 0.001). Overall, 62.4% children with bridled NGTs and 77.1% children with unbridled NGTs progressed to full oral feedings and discontinued therapy (*P* < 0.001). Adverse skin outcomes were rare in both groups.

Conclusion: Children with bridled NGTs experienced fewer dislodgments, hospital days, ED encounters, and radiographic exposures than unbridled NGTs. Most children in both groups progressed to full oral feedings.

KEYWORDS

enteral nutrition, enteral tube dislodgment, enteral tube securement, pediatric

CLINICAL RELEVANCY STATEMENT

Nasogastric tube bridles are rarely used in children, and even more rarely are these patients sent home using bridles as a securement device. This article demonstrates the effectiveness and enhanced safety of nasal bridling of nasogastric tubes in children with a variety of diagnoses.

INTRODUCTION

Nasogastric tubes (NGTs) are commonly used to provide temporary enteral nutrition support and/or are used before placement of a durable tube.¹⁻⁷ Children with complex medical concerns may have NGTs for weeks or months, which are managed across a variety of disciplines.^{3,5,7-11} Children who are discharged home with NGTs often experience tube dislodgment¹⁰⁻¹⁴ that requires families to seek medical assistance for accurate replacement, which may involve additional radiological exposure and increased healthcare costs.¹¹ Children requiring enteral nutrition support through NGTs pose specific challenges to prevent the tube from being dislodged.^{10,11,14,15} The incidence of NGT dislodgment across all age groups, including adults, has been reported to be 40%–68%.¹⁶⁻¹⁹

Hospitals are often hesitant to send infants home with NGTs owing to the 40%–50% likelihood of inadvertent removal,¹³⁻¹⁵ resulting in increased gastrostomy tube (GT) placement or longer hospital stay for patients trying to achieve full oral intake. Current research supports nasal bridling as an effective method to secure NGTs in adults,²⁰⁻³⁴ although only three small studies have demonstrated the efficacy of nasal bridles to secure NGTs in just over 80 children.^{13,14} Recently, we described the initiation of a pediatric nasal bridle program at our pediatric tertiary medical center; the policy and procedure for bridling NGTs is included in the supplement of that original paper.³⁵

Traditionally, there has been hesitancy regarding the use of nasal bridles owing to concerns about discomfort, skin integrity, insertion procedure methods, and parental opinions. The nasal bridle was developed in the 1980s as a method to secure NGTs, and newer materials and methodology have made placement smoother and easier.³⁶⁻³⁹ The purpose of this study was to determine whether nasal bridling improves tube-related outcomes in children requiring NGT placement.

METHODS

This was a retrospective, correlational study. Data were extracted from medical records of patients receiving an NGT at a large Midwestern regional children's hospital over a 2-year period (March 2018 through August 2020). Data analysis compared NGT-relevant outcomes in patients with NGTs secured with bridles or traditional methods such as taping. Specifically, this study compared length of inpatient hospital stay (LOS), the end point of GT placement, episodes of tube dislodgment/replacement, emergency department

(ED) encounters, radiographic exposures, and reported adverse effects on nasal and skin integrity. Children with NGTs secured with tape served as concurrent controls to minimize variation in medical management. Any patient who had either a bridled or unbridled NGT for longer than 7 days was considered for the study. This study was approved by the institutional review board (IRB #1649197).

Children were classified into two groups: the study group with bridled NGTs or the concurrent control group with unbridled NGTs. It is the institution's practice for the primary care team to decide how they would like to secure the NGT. The institution's approach to bridled NGTs is to do so, per the primary team's preference and after consultation with the multidisciplinary team, for patients expected to require an NGT at home. When a bridle is being considered, consultants for clinical nutrition, speech therapy, gastroenterology, and enteral feeding are included, and this multidisciplinary team decides whether the placement of a bridle is best for that particular patient. The hospital follows a protocol for standard placement of bridled NGTs. Clinicians who place bridles are typically registered nurses or nurse practitioners who have been trained or credentialed to perform the procedure. A procedure to place a bridle may occur inpatient on any unit, outpatient in the Enteral Feeding Clinic, and at times in Special Procedures, Interventional Radiology, or the operating room.

The end point for each child was either achievement of 100% oral feeds or transition to a durable GT. Children with nasojejunal tubes and tubes used for purposes other than nutrition provision were excluded from the study. There were 128 children who received an unbridled NGT that was then converted to a bridled NGT. In these children, we analyzed only the bridled-NGT portion of their therapy to maintain two mutually exclusive groups for analysis. For patients who initially experienced an unbridled NGT and then went on to experience a bridled NGT, this decision was made for a variety of reasons: primary team preference, medical requirement for prolonged NGT use, trial to see whether the child could achieve 100% oral intake, or frequent dislodgment. Figure 1 describes the selection process for patient records for the purpose of this study.

Data collection methods

Patients were identified and tracked through order sets and Line, Drain, and Airway flowsheets built into the electronic health record. Those orders were then compared to *International Classification of Diseases* (ICD) codes for the patients. Categorical or binary data collected included sex, insurance status, primary inpatient service, and primary diagnosis at the time of therapy initiation. Continuous variables included age (weeks) at initiation of therapy as well as at the time of final tube removal, weight (kilograms) and length (centimeters) at the time of first tube insertion and final tube removal, and anthropometric z score at the time of NGT therapy initiation.^{40,41} For premature infants, we used the Fenton growth chart to assess weight-for-age z score. For full-term infants, age 0 through 24 months, we used the World Health Organization (WHO) growth chart to assess weight-for-length z score. Finally, for children age >24 months, the Centers for Disease Control

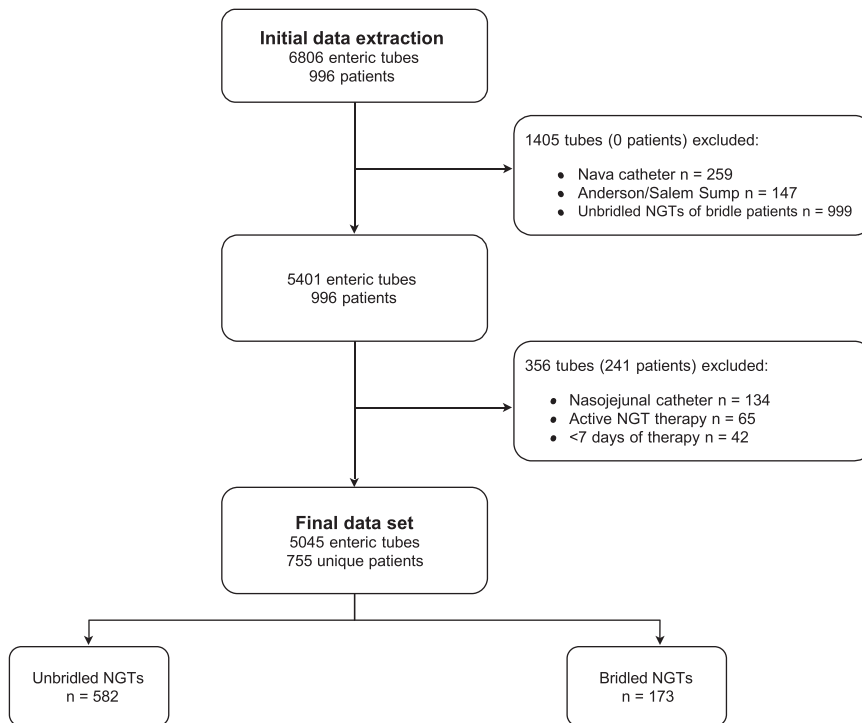


FIGURE 1 Flow diagram of patients with nasogastric tubes (NGTs) and bridles

and Prevention (CDC) growth chart was used to assess z score for body mass index for age. Because weight-for-length z score is not available for premature infants, we used the weight-for-age z scores as a proxy for nutrition status. Each z score was categorized as follows: <-3.0 indicates severe malnutrition, ≤-2 indicates moderate malnutrition, ≤-1.0 indicates mild malnutrition, and >-1.0 indicates normal nutrition.^{40,41}

The total duration of a patient's NGT episode for enteral nutrition began at initial NGT placement, for which feeding lasted ≥ 7 days, and ended when the child either achieved full oral intake or transitioned to a GT; this included postdischarge days with a tube in place. Each tube removal was tracked and labeled as a dislodgment, purposeful removal, by-mouth trial, or final tube removal. Dislodgments were defined as unintentional removals of the NGT and occurred for multiple reasons: emesis, snagging on equipment, and accidental pulling by caretaker/staff. A tube was coded as a dislodgment if the child inadvertently or intentionally pulled out the tube. Specifically, dislodgments did not include purposeful removals. A purposeful removal was defined as a provider decision to remove the tube. This occurred in the neonatal intensive care unit (NICU) every 7 days per institutional policy to replace tubes once weekly to mitigate the risk of necrotizing enteric colitis and infection.⁴² In every other unit, purposeful removals occur, on average, every 30 days or for other patient-specific reasons. Each final tube removal was also tracked as the end of NGT therapy. The total number of days that the NGT was in place and the total number of tubes needed throughout their NGT therapy were calculated. The total number of tubes is equal to the number of tubes each patient had throughout therapy, which equals the number of times a tube was replaced because of either a dislodgment or a routine replacement. ED encounters were

enumerated as an independent variable of interest and were only included if the visit was recorded as being related to a concern with the tube. Concerns about skin integrity and abdominal x-rays used to confirm placement were tabulated.

Data analysis and rationale

The data were analyzed using IBM SPSS Statistics for Windows (Version 27) predictive analytics software. Descriptive statistics were used to describe demographic characteristics of the two groups. Categorical and dichotomous variables were expressed as number and percentage. Continuous variables were expressed by depicting mean and SD. The odds ratio (OR) and chi-square *P* value were expressed for each categorical variable, and Cohen's *d* and correlating *P* value were analyzed for each continuous variable to compare groups. Analysis of outcome data was conducted using the generalized linear models (GLMs) family of analyses. This series of predictive models predicted the score of an observed outcome for the patients, based on selected, clinically relevant predictors. Through evaluating the relevance of the overall model and each predictor based on tests for null hypotheses and effect-size measures, both elements were considered in determining whether a predictor has a relevant impact on the outcome. For the null-hypothesis test of each predictor, we used a significance level of 0.05 as a threshold to reject the null hypothesis.

Negative binomial regression was used for the following outcomes: number of dislodgments, LOS, ED encounters, and radiographic exposures. As a GLM, the overall model would be evaluated with a

pseudo- R^2 method, and each of the predictors was evaluated with a null-hypothesis test. The exponent of the slopes presents the incident rate ratios, representing the ratio change that can be transformed into probability change for interpretation.^{43,44}

All regression models for each hypothesis were initially tested using the outcome variable of interest comparing only the two groups: bridled NGTs compared with unbridled NGTs. Each hypothesis was then tested by adding clinically relevant predictors into each regression model. Clinically significant covariates relevant to enteral nutrition remained in the model if the *P* value was <0.05.

RESULTS

Descriptive and comparative statistics

There were 755 unique children in the study (173 children in the group with NGT bridles group and 582 concurrent controls). Participant demographic comparisons can be seen in Table 1, and participant outcome characteristics can be seen in Table 2. Children with bridled NGTs were more likely to be female, to not be in the NICU, and to not be born prematurely. Similarly, the ages and weights at initiation and termination of NGT therapy were higher in the children with bridled NGTs.

Children with bridled NGTs had an initial hospital stay that was significantly shorter than that of the cohort with unbridled NGTs, but the number of outpatient days of therapy was significantly higher in the cohort with NGT bridles. Hence, the group with NGT bridles demonstrated a significantly longer duration of total tube days through the course of therapy. The number of tubes required throughout therapy duration and the total number of dislodgments were significantly lower in the group of children with bridled NGTs. Additionally, the number of radiographic exposures in the group of children with bridled NGTs was significantly shorter than in the concurrent control group. Neither group experienced significant concerns about skin integrity related to the bridle.

Based on categories of anthropometric *z* scores, 4.1% ($n = 7$ of 171) of children with bridled NGTs were severely malnourished at the time of initiation of enteral nutrition therapy, compared with 2.3% ($n = 13$ of 579) of children with unbridled NGTs. The majority of both cohorts were not found to be at risk for malnutrition at the time of initiating enteral nutrition therapy (66.67% with bridled NGT and 69.94% with unbridled NGT). At the time of therapy initiation, children with bridled NGTs were, on average, 25 weeks older and 2.5 kg larger than their counterparts with unbridled NGTs. At therapy completion, both the cohorts with and without bridled NGTs demonstrated significant weight gain after therapy, 1.19 and 1.15 kg, respectively.

Two of the outcome variables were analyzed by the securement group per 100 days. Children in the bridled-NGT group had a collective total of 10,878 days with a tube. Children with unbridled NGTs had a total of 26,395 tube days. Children with bridled NGTs exhibited 0.52 dislodgments per 100 days, compared with children with unbridled

NGTs, who exhibited 10.43 dislodgments per 100 days. Additionally, the number of NGT-related ED encounters per 100 days by group was 0.12 ED encounters per 100 days in children with bridled NGTs and 0.20 visits per 100 days in the children with unbridled NGTs.

Dislodgments

Children with bridled NGTs had a significantly lower number of tube dislodgments compared with children with unbridled NGTs during the course of therapy. Those with bridled NGTs were 16.67 times less likely to experience one more dislodgment than their counterparts with unbridled NGTs, when tested in a negative binomial regression model controlling for primary inpatient service, sex, anthropometric *z* score, and age upon initiation of therapy. The covariates that were statistically significant in the model were a bridle and critical care service (Table 3).

LOS

Children with bridled NGTs were found to have a significantly lower number of initial LOS days compared with the unbridled-NGT group. Children with a bridled NGT were 1.54 times less likely to have an additional day in the hospital during the initiation of their enteral nutrition therapy, when tested in a negative binomial regression model controlling for primary diagnosis, insurance status, anthropometric *z* score, and age upon initiation of therapy. The predictors in the model that were significant were securement type, primary diagnosis, and anthropometric *z* score (Table 4).

ED encounters

When number of ED encounters was tested in a negative binomial regression model, controlling for number of outpatient therapy days, the model was significant (Table 5). Children with bridled NGTs were 2.5 times less likely to have one more ED encounter than their counterparts with unbridled NGTs.

In addition, the percentage of children with bridled NGTs who experience an ED encounter exponentially declined every 6 months since the inception of the bridle program at our institution (Figures S1 and S2 depict five 6-month periods of time in which number of ED encounters was tracked for children in both groups). The percentage of children with bridled NGTs who experienced ED encounters over time has decreased by 93.9% since March 2018 (Figure S1).

Skin integrity concerns

There was only one documented skin-integrity concern reported in the data in the bridled-NGT group and none in the unbridled-NGT group.

TABLE 1 Participant characteristics

Characteristic	Bridled NGT	Unbridled NGT	Total	Cohen's <i>d</i> or OR (P value)
Age at therapy initiation, M (SD), weeks	36.45 (51.15)	11.41 (35.30)	17.15 (40.87)	-0.63 (<0.001)
Range (min-max)	0.29-238	0-273.14	0-273	
Age at therapy completion, M (SD), weeks	46.42 (52.38)	19.83 (37.73)	25.92 (42.99)	-0.64 (<0.001)
Range (min-max)	2.86-276.29	1.14-284.29	1.14-284.29	
Weight at therapy initiation, M (SD), kg	5.75 (3.02)	3.24 (3.26)	3.81 (3.38)	-0.78 (<0.001)
Range (min-max)	2.17-17	0.43-26.5	0.43-26.5	
Weight at therapy completion, M (SD), kg	6.94 (3.01)	4.39 (3.23)	4.97 (3.35)	-0.80 (<0.001)
Range (min-max)	2.46-17.2	1.04-28.6	1.04-28.6	
Anthropometric z score, M (SD)	-0.46 (1.44)	-0.35 (1.36)	-0.37 (1.38)	0.08 (0.357)
Range (min-max)	-3.77-3.25	-6.91-3.96	-6.91-3.96	
Sex, N (%)				OR = 0.61 (0.004)
Female	96 (55.5)	251 (43.1)	347 (46.0)	
Male	77 (44.5)	331 (56.9)	408 (54.0)	
Insurance status, N (%)				OR = 0.76 (0.105)
Commercial	70 (40.5)	242 (41.6)	312 (41.3)	
Medicaid	79 (45.7)	293 (50.3)	372 (49.3)	
Combination	24 (13.9)	46 (7.9)	70 (9.3)	
Primary service ^a , N (%)				OR = 0.25 (0.001)
Critical care	8 (4.6)	100 (17.2)	108 (14.3)	
NICU	77 (44.5)	411 (70.6)	488 (64.6)	
Acute care	58 (33.5)	42 (7.2)	100 (13.2)	
Ambulatory	22 (12.7)	3 (0.5)	25 (3.3)	
Other	8 (4.6)	26 (4.5)	34 (4.5)	
Primary diagnosis ^b , N (%)				OR = 0.62 (0.002)
Cardiac	11 (6.4)	81 (13.9)	92 (12.2)	
Respiratory	12 (6.9)	52 (8.9)	64 (8.5)	
GI/nutrition	55 (31.8)	27 (4.6)	82 (10.9)	
Prematurity	50 (28.9)	298 (51.2)	348 (46.1)	
Congenital anomaly	24 (13.9)	73 (12.5)	97 (12.8)	
Other	21 (12.1)	51 (8.8)	72 (9.5)	
Final mode of nutrition, N (%)				OR = 2.03 (0.001)
GT	65 (37.6)	133 (22.9)	198 (26.2)	
Oral	108 (62.4)	449 (77.1)	557 (73.8)	

Note: Cohen's *d* reported for all continuous variables and OR reported for all categorical variables. Chi-square test was used to statistically analyze differences between groups. *P* value statistically significant at ≤ 0.05 .

Abbreviations: GI, gastrointestinal; GT, gastrostomy tube; M, mean; NGT, nasogastric tube; NICU, neonatal intensive care unit; OR, odds ratio.

^aOther Primary Service includes interventional radiology, transport, at home, emergency department, and operating room.

^bOther Primary Diagnoses include hematology, oncology, infection, neurological, and trauma.

TABLE 2 Participant outcomes

Characteristic	Bridled NGT, M (SD)	Unbridled NGT, M (SD)	Total, M (SD)	Cohen's <i>d</i> (P value)
Total tube days	62.88 (54.08)	45.35 (42.28)	49.37 (45.81)	-0.39 (<0.001)
Length of stay, days	28.40 (40.34)	53.92 (52.79)	48.07 (51.32)	0.51 (<0.001)
Dislodgments, <i>n</i>	0.33 (0.62)	4.73 (4.76)	3.72 (4.58)	1.05 (<0.001)
Total number of tubes	2.36 (1.71)	7.99 (6.27)	6.70 (6.05)	1.01 (<0.001)
Skin integrity concerns, <i>n</i>	0.01 (0.11)	0.00 (0.00)	0.00 (0.05)	-0.23 (0.009)
Radiographic exposures, <i>n</i>	0.20 (0.44)	1.00 (1.23)	0.82 (1.15)	0.72 (<0.001)
Outpatient days of therapy	82.89 (94.19)	15.26 (56.07)	30.75 (72.50)	-1.01 (<0.001)
Emergency department encounters, <i>n</i>	0.08 (0.29)	0.09 (0.54)	0.09 (0.49)	0.33 (0.707)

Note: P value ≤ 0.05 is considered statistically significant for these chi-square tests.

Abbreviations: M, mean; NGT, nasogastric tube; OR, odds ratio.

TABLE 3 Negative binomial regression model: Tube dislodgments

Covariate	Coefficient (β)	SE	P value	OR (95% CI)
Intercept	1.55	0.21	<0.001	4.72 (3.10–7.21)
Bridle	-2.77	0.18	<0.001	0.06 (0.04–0.09)
Primary service ^a				
Acute care	0.62	0.27	0.817	1.06 (0.63–1.81)
Ambulatory	0.40	0.43	0.359	1.49 (0.64–3.45)
Critical care	-0.95	0.25	<0.001	0.39 (0.24–0.63)
NICU	0.12	0.22	0.570	1.13 (0.74–1.73)
Sex ^b	0.01	0.09	0.940	1.01 (0.84–1.20)
Anthropometric z-score ^c	0.00	0.03	0.927	1.00 (0.93–1.07)
Age ^d	-7.19	0.00	0.962	1.00 (1.00–1.00)

Note: Dependent variable: number of nasogastric tube (NGT) dislodgments per child ($N = 750$). Outcome of testing association between numbers of NGT dislodgments based on securement method when controlling for primary service, sex, anthropometric z score, and age. Goodness-of-fit $\chi^2(10) = 399.80$, $P < 0.001$.

Abbreviations: OR, odds ratio; SE, standard error.

^aPrimary service is compared with other (interventional radiology, transport, at home, emergency department, and operating room).

^bSex refers to female patients compared with male patients.

^cAnthropometric z score was recorded upon initiation of NGT therapy.

^dAge, in weeks, at the time of NGT therapy initiation.

Radiographic exposures

Children with bridled NGTs experienced less radiation exposure than their counterparts with unbridled NGTs. Negative binomial regression modeling was used to analyze whether there was an association between the number of x-rays taken to confirm accurate NGT placement during therapy based on the type of securement method when controlling for primary service at the time of initial NGT insertion, outpatient therapy days, initial LOS, and age at the time of

therapy initiation (Table 6). Children with bridled NGTs were found to be 4.76 times less likely to have one more x-ray than their counterparts with unbridled NGTs. The model was significant for the following predictors: ambulatory primary service compared with other (OR = 0.21, $P = 0.022$), NICU primary service compared with other (OR = 0.51, $P = 0.008$), outpatient therapy days (OR = 1.01, $P < 0.001$), and initial LOS (OR = 1.01, $P < 0.001$).

DISCUSSION

The patient outcome data obtained in the present study suggest that the use of bridled NGTs in infants and children up to age 6 years is safe and effective. This particular bridle is approved for use in all ages. However, the difference in ages between the two groups is based on institutional preference for clinicians to provide bridles for patients before discharge home. As a result, the group with NGT bridles is older, on average, than the cohort without NGT bridles (Table 1). This study offers a new perspective on bridled NGTs in the pediatric population and is the largest study to date. Bridled NGTs in this population were associated with a significantly lower number of NGT dislodgments. The LOS for children with bridled NGTs was significantly lower than for children with unbridled NGTs, as were the number of ED visits. Concerns about skin integrity were negligible in both groups. The number of x-rays needed was significantly lower for the children with bridled NGTs as well, resulting in significantly lower levels of radiation exposure.

Dislodgments are a significant concern with NGTs and have traditionally been the reason infants and children are not readily discharged with them. Also, when these dislodgments occur, they can lead to a cascade of events such as ED visits and cessation of nutrition therapy until the NGT is replaced and also to potentially more catastrophic events such as malposition of the NGT when it is replaced, leading to significant aspiration. It appears from our study that NGT dislodgment can be significantly reduced by bridling these tubes. This then follows that the number of ED encounters also was

TABLE 4 Negative binomial regression model: Inpatient length of stay

Covariate	Coefficient (β)	SE	P value	OR (95% CI)
Intercept	3.62	0.13	<0.001	37.16 (28.63–48.23)
Bridle	–0.44	0.10	<0.001	0.65 (0.54–0.78)
Primary diagnosis ^a				
Cardiac	0.79	0.17	<0.001	2.20 (1.59–3.07)
Congenital	0.49	0.17	0.004	1.63 (1.18–2.27)
GI/nutrition	–0.83	0.18	<0.001	0.44 (0.31–0.62)
Prematurity	0.59	0.14	<0.001	1.80 (1.36–2.39)
Other ^b	0.99	0.18	0.583	1.10 (0.78–1.58)
Insurance status ^c				
Combination	–0.11	0.13	0.423	0.90 (0.69–1.17)
Commercial	–0.16	0.08	0.053	0.85 (0.73–1.00)
Anthropometric z-score ^d	0.05	0.03	0.042	1.06 (1.00–1.11)
Age ^e	–0.00	0.00	0.182	1.00 (1.00–1.00)

Note: Dependent variable: number of days spent in the hospital per child ($N = 749$). Outcome of testing association between numbers of days in hospital upon therapy initiation based on securement method when controlling for primary diagnosis, insurance status, anthropometric z score, and age. Goodness-of-fit $\chi^2(10) = 80.29$ ($P \leq 0.001$).

Abbreviations: GI, gastrointestinal; OR, odds ratio; SE, standard error.

^aPrimary diagnosis is compared with respiratory disease.

^bOther diagnoses include hematology, oncology, infection, neurological, and trauma.

^cInsurance type is compared with Medicaid.

^dAnthropometric z score was recorded upon initiation of nasogastric tube (NGT) therapy.

^eAge, in weeks, at the time of NGT therapy initiation.

TABLE 5 Negative binomial regression model: Emergency department encounters

Covariate	Coefficient (β)	SE	P value	OR (95% CI)
Intercept	–2.83	0.17	<0.001	0.06 (0.04–0.08)
Bridle	–0.92	0.37	0.013	0.40 (0.19–0.82)
Outpatient days ^a	0.01	0.00	<0.001	1.01 (1.01–1.01)

Note: Dependent variable: number of emergency department encounters per child ($N = 755$). Outcome of testing association between numbers of emergency department encounters based on securement method when controlling for number of outpatient days. Goodness-of-fit $\chi^2(2) = 61.27$ ($P \leq 0.001$).

Abbreviations: OR, odds ratio; SE, standard error.

^aOutpatient days are number of days of therapy spent outside of the hospital during treatment.

far less in children with bridled NGTs. A bridled NGT does not prevent an NGT from being vomited out (in its entirety). In this case, the NGT and bridle must be removed. These patients likely went to the ED to have the bridled NGT removed, and this was counted as a dislodgment for the purposes of this study. Our institution does not train parents to replace NGTs at home. Every time a new NGT is placed in the hospital, ED, or ambulatory setting, a new entry must be made in the electronic health record. However, it is possible that this

documentation did not occur for every single dislodgment. Even if this did happen, it is far less likely that this happened in children with bridles, as the method of changing these is far more complicated than changing out just the NGTs. Also, most other EDs in the area do not have the ability to change NGTs in children with bridles, and hence, if any of these were replaced without concomitant changes in the electronic health record, it likely occurred rarely and with solely the unbridled NGTs.

Our model, which controlled for the number of outpatient therapy days, showed that children with bridled NGTs were 2.50 times less likely to have one more ED visit than a child with an unbridled NGT. Like many other innovations, it is likely that bridling of NGTs has a learning curve, and our institution went through this process. As the nasal bridle program became fully operational and expanded throughout the medical center, families were better supported, additional providers became credentialed in the procedure, and educational materials were more robust, which may have contributed to the lower incidence of ED encounters in the cohort with bridled NGTs. Both groups had access to the enteral feeding team in a more robust fashion during normal business hours. Even with this, the percentage of children with unbridled NGTs who had an ED encounter over time has not drastically decreased (Figure S2). The percentage of children with unbridled NGTs who visit the ED consistently ranged from 7% to 12% throughout the duration of the study (Figure S2).

TABLE 6 Negative binomial regression model: Radiographic exposure

Covariate	Coefficient (β)	SE	P value	OR (95% CI)
Intercept	0.17	0.25	0.50	1.18 (0.72–1.94)
Bridle	-1.54	0.21	<0.001	0.21 (0.14–0.33)
Primary service ^a				
Acute care	-0.56	0.32	0.077	0.57 (0.31–1.06)
Ambulatory	-1.57	0.69	0.022	0.21 (0.05–0.80)
Critical care	-0.47	0.28	0.093	0.63 (0.36–1.08)
NICU	-0.67	0.25	0.008	0.51 (0.31–0.84)
Outpatient days ^b	0.00	0.00	<0.001	1.00 (1.00–1.01)
Length of stay ^c	0.00	0.00	<0.001	1.01 (1.00–1.01)
Age ^d	0.00	0.00	0.70	1.01 (1.00–1.01)

Note: Dependent variable: number of radiographic exposures related to nasogastric tube (NGT) placement per child ($N = 755$). Outcome of testing association between numbers of x-rays taken to confirm proper NGT placement during therapy based on securement method when controlling for primary service, outpatient days, length of stay, and age. Goodness-of-fit $\chi^2(8) = 141.47$ ($P \leq 0.001$).

Abbreviations: NICU, neonatal intensive care unit; OR, odds ratio; SE, standard error.

^aPrimary service is compared with other (interventional radiology, transport, at home, emergency department, and operating room).

^bOutpatient days are number of days of therapy spent outside of the hospital during treatment.

^cLength of stay is the number of inpatient hospital days at the time of initial NGT placement.

^dAge, in weeks, at the time of NGT therapy initiation.

For the current cohort of 173 children with bridled NGTs, 62.4% ($N = 108$) went on to achieve full oral feeds and left the hospital, on average, 14 days earlier than children with unbridled NGTs, when accounting for clinically relevant predictors in the model. However, this is complex because children traditionally had their NGTs bridled as they were approaching discharge. Children were discharged soon after bridle placement because the providers were more confident with the method of securement in the home setting. It is also important that children with NGT bridles had longer outpatient times before either achieving full feeds or transition to durable tubes. This is in keeping with the fact that the securement method of the NGT (bridled or unbridled) has no direct association with whether a GT needs to be placed. This decision is made based on the ability of the child to feed and grow without additional supplementation. Traditionally, 30%–40% of children with NGTs do not require eventual GT placement; therefore, bridles are an option that should be considered for children as they develop oral-motor skills to possibly reach their goals of full oral intake. The role of the bridled NGT is to provide stable enteral access during the period of time that the child is given the opportunity to achieve feeding goals.

Rashes, redness, and dryness can be a common concern for infants and children using tape on their face to secure tubing of any kind. For the

purposes of this study, incident reports and skin integrity documentation in the electronic health record were used to uncover these concerns. As reported, only one of the 755 children had a documented concern about skin integrity. Likely, additional children experienced less critical skin issues. It is important to recognize that these skin concerns may go undocumented or even untreated in this population. The recommendation for all bridled NGTs is to not use facial tape and therefore preserve the integrity of delicate skin. Conversely, the monofilament tube of the bridle has been known to erode through the nasal cartilage and cause significant injury as well. Consultation by a skin assessment team upon placement of any NGT could be deployed across an institution to improve the awareness and documentation of skin-integrity concerns related to NGT placement, for both bridled and unbridled tubes.

Anecdotally, there has been concern that bridle placement is barbaric and should be avoided in children; this is likely based on older versions of the bridle that were difficult to place. However, it has been our experience that placement of the current iteration of the bridle adds approximately 2 min to the overall placement of an NGT. Like NGT placement in itself, occasionally the procedure takes longer, for putative reasons of anatomy. The amount of distress is difficult to quantify but appears not much greater than that caused by the NGT itself. Also, based on our data, the bridle is associated with far fewer replacements, and this should be factored into the discussion of distress caused by bridle placement. Overall, we believe that the bridle in its current form is a useful addition to the armamentarium.

As many hospitals move toward a value-based care model and strive to provide higher-quality care at a lower cost, many pediatric hospitals are seeking new strategies for providing long-term nutrition care. Discharging patients home with temporary feeding tubes allows children to work on oral-motor skill development in their home environment and avoid the high cost of an inpatient hospital stay. Based on the results of this study, we believe that bridles are efficacious in infants at 36 weeks' gestation and all older children. The patient population in which bridles may be used is diverse and includes but is not limited to children with congenital heart disease, children after surgery, and critically ill children. Children who are being discharged with NGTs, in particular, should be considered for bridles.

Limitations

There were several limitations to this study. Retrospective studies are prone to misclassification bias, as the data are not reported or collected in real time. There was no purposeful selection or randomization between groups; therefore, the ability to create a homogenous demographic sample between groups was not feasible. Additionally, the two groups differed in age at therapy initiation. Finally, data abstracted from the medical record could be incomplete or incorrect.

Another limitation of this study is that 128 children experienced both an unbridled NGT and a bridled NGT during

their enteral nutrition therapy. For each of these children, only the bridled NGT portion of their care was entered into the final data set. As mentioned before, it is likely that LOS was shorter in children with bridles, but given the retrospective nature of our study and the fact that we included children who had both an unbridled NGT and a bridled NGT, it is not definitively conclusive. For the purposes of this study, ED encounters related to the tube were tracked. It is possible that children followed up in additional ambulatory clinics for NGT-related concerns and that this was not tracked. Additionally, ED encounters could have been coded for something other than NGT concerns, when indeed the NGT was manipulated or changed. Finally, it is also possible that patients sought out care at other facilities that were not available in the electronic medical record. These data elements were then also unavailable to the researcher.

Further research with a larger sample size, involving other institutions and other pediatric patient populations, is needed to determine the generalizability of the findings of this study. Qualitative research addressing parental and provider concerns with bridling could be an additional research opportunity. Finally, a review of the financial impact of bridle use is also worthy of future review.

CONCLUSION

Based on the results of this retrospective study conducted using medical records at one tertiary academic medical center, the bridling of NGTs in pediatric patients was found to be a safe and effective method of securing NGTs. Bridling NGTs resulted in a decrease in the number of dislodgments, ED encounters, and radiographic exposures. These findings suggest the efficacy and safety of nasal bridles as a means of securing NGTs in the pediatric population. More research needs to be conducted in a larger sample size, involving other institutions and other pediatric patient populations, to continue to determine the generalizability of the findings of this study.

AUTHOR CONTRIBUTIONS

Julie Ann Lavoie, Christine Schindler, Mauricio Garnier-Villarreal, Donna O McCarthy, and Praveen S. Goday contributed to the conception and design of the research; Julie Ann Lavoie and Sravya Patil Bagli contributed to the acquisition and analysis of the data; Julie Ann Lavoie, Christine Schindler, and Mauricio Garnier-Villarreal also contributed to the analysis of the data; Julie Ann Lavoie, Christine Schindler, Mauricio Garnier-Villarreal, Donna O McCarthy, and Praveen S. Goday all contributed to the interpretation of the data. All authors drafted the manuscript, critically revised the manuscript, agree to be fully accountable for ensuring the integrity and accuracy of the work, and read and approved the final manuscript.

CONFLICT OF INTEREST

Praveen S. Goday serves as a consultant to Takeda Pharmaceuticals. The remaining authors have no financial relationships relevant to this article to disclose.

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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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