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Nipple Shields for Preterm Infants: Effect on Milk Transfer and Duration of Breastfeeding

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Abstract

This study reports breastfeeding outcomes for 34 preterm infants whose mothers used ultra-thin silicone nipple shields to increase milk transfer. Mean milk transfer was compared for 2 consecutive breastfeedings without and with the nipple shield. Total duration of breastfeeding was calculated for a maximum of 365 days. Mean milk transfer was significantly greater for feedings with the nipple shield (18.4 ml vs. 3.9 ml), with all 34 infants consuming more milk with the nipple shield in place. Mean duration of nipple shield use was 32.5 days, and mean duration of breastfeeding was 169.4 days; no association between these variables was noted. The nipple shield was used for 24.3% of the total breastfeeding experience, with no significant association between the percentage of time the shield was used and total duration of breastfeeding. These findings are the first to indicate that nipple shield use increases milk intake without decreasing total duration of breastfeeding for preterm infants. *J Hum Lact* 2000;16(2): 106-114.

Keywords: preterm infant, nipple shield, milk volume, premature, breastfeeding

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Recent studies indicate that preterm infants receive highly specific health benefits when they are fed their own mothers' milk as compared to commercial formula. These benefits include greater enteral feed tolerance¹⁻⁴; reduced risk and/or severity of infection,^{4,5-10} necrotizing enterocolitis,^{2,11-17} and atopic disease^{18,19}; enhanced retinal maturation²⁰⁻²³ and neurocognitive outcome^{20,22,24-30}; and greater physiologic stability during breastfeeding than during bottle feeding.³¹⁻³⁶ However, mothers of preterm infants encounter well-documented barriers to breastfeeding, making them less likely to initiate and sustain lactation than comparable populations of women with healthy, term infants.³⁷⁻³⁹ Although many of these barriers are preventable, others—such as immature feeding behaviors—reflect maturity-dependent physiologic differences between term and preterm infants.⁴⁰ Immature feeding behaviors, such as short, ineffective sucking bursts and falling asleep immediately after

being positioned at breast, predispose the preterm infant to underconsumption of milk with exclusive at-breast-feeding until approximately term, corrected age.⁴⁰⁻⁴⁴ Temporary strategies are needed to facilitate milk intake and sustain lactation until preterm infants reach their expected birth dates and feed like healthy, term infants.

One strategy that may be helpful in compensating for immature feeding behaviors is the use of small, thin, silicone nipple shields.⁴⁵ Anecdotally, the nipple shield corrects flat and/or large nipples, making it easier for the preterm infant to maintain attachment to the breast and extract milk. The nipple shield is less pliable than the maternal nipple, so the preterm infant does not slip off the breast during pauses in sucking bursts. As a result, shield use appears to increase both the duration of sucking bursts and the volume of milk consumed during breastfeeding for preterm infants.⁴⁶

Although little systematic research has been conducted with nipple shields, lactation specialists have discouraged their use^{47,48} for three major reasons. First, nipple shields are thought to reduce milk transfer to the infant and to prevent complete breast emptying. Second, they are considered addictive in that once introduced, infants may prefer the shield to the breast, making it difficult to discontinue its use. Finally, the combination of incomplete breast emptying and infant preference for the nipple shield is thought to decrease the mother's milk yield over time, resulting in early unplanned weaning.

The purpose of this study is to report breastfeeding outcomes for 34 preterm infants and mothers who used nipple shields to facilitate milk intake during and/or after each infant's stay in a neonatal intensive care unit (NICU). In this retrospective, multicenter project, we compared volume of milk transfer for consecutive breastfeedings without and with the nipple shield and measured the number of days that the shield was used as a breastfeeding aid. Finally, we calculated total duration of breastfeeding for these infants and compared this figure with national and international statistics.

This project was supported by National Institutes of Health Grant NR03881 and a research grant from Medela, Inc. (McHenry, Ill). The investigators acknowledge the assistance of Dr. Chantal Lau for her conceptualization of the mechanics of milk transfer with the nipple shield.

Potential competing interests: This study was funded in part of Medela, Inc. to address breastfeeding outcomes with in-home measurement of milk intake for preterm infants. This company also manufactures nipple shields.

Literature Review

Women have used nipple shields to manage inverted, infected, or ulcerated nipples since the mid-16th century.^{49,50} Historically, these devices were made of tin, lead, silver, or wood, and occasionally they were covered with the "pap of a new killed cow."⁴⁹ In the mid-1900s, newer-model latex shields were used indiscriminately by maternity nurses to correct an array of breastfeeding problems.⁴⁸ The low rates of breastfeeding duration that characterize this time period are often linked to widespread inappropriate nipple shield use; however, the effect of the shield cannot be isolated from the absence of expert breastfeeding assistance that characterized hospital environments during this time.

A few studies have suggested that nipple shields reduce milk transfer to the infant,⁵¹⁻⁵⁴ but none have included a sample of mothers and infants with breastfeeding problems prior to shield use. In one frequently cited investigation,⁵¹ milk transfer during actual infant feeding at breast was not studied due to the investigator's concern that one-time nipple shield use and measurement of milk transfer would interrupt successful breastfeeding. Instead, milk transfer was compared with and without the shield for mothers who used an electric breast pump.

In three separate well-controlled studies that reported less milk intake when the nipple shield was used, the samples consisted of healthy term newborns and/or older infants who were breastfeeding effectively without the shield.⁵²⁻⁵⁴ For ethical reasons, investigators specifically chose populations of experienced breastfeeding mothers and older infants whose suckling was unlikely to be interrupted by the nipple shield intervention. In these studies, a latex shield was placed over the mother's breast for a single breastfeeding during which milk transfer was measured and compared with a feeding without the shield. Although these studies confirmed that infants consumed less milk with the shield in place, it is important to recognize that these infants had never demonstrated breastfeeding problems for which the nipple shield may have been helpful. Instead, it is likely that the nipple shield interrupted well-established breastfeeding patterns for these infants and mothers.

This hypothesis is supported by one of the three controlled trials in which maternal concentrations of serum cortisol and prolactin were measured at sequential time points over the course of breastfeedings with and without the nipple shield.⁵² The only statistically significant differences in mean values were early in the feedings for

serum cortisol, which was significantly higher for the nipple shield feeding. This finding led investigators to speculate that shield use may have induced a stress response for women who were unaccustomed to it. Thus, the elevated serum cortisol early in the feeding with the shield may have affected the maternal oxytocin response, reducing the total milk available to infants.

Another limitation of these studies is that milk transfer with the nipple shield was measured for only a single breastfeeding. Without longitudinal data, it is impossible to determine whether infants and mothers would have adapted to its use, demonstrating adequate infant intake and maternal milk production. However, clinicians have interpreted these findings to mean that reduced milk transfer with the shield is cumulative, resulting in decreased maternal milk volume and early, unplanned weaning. It is important to recognize that no empirical evidence supports this speculation.

A final consideration that limits generalizability of these studies⁵²⁻⁵⁴ is that they were conducted with older-model latex nipple shields. These devices were thicker and less pliable than the ultrathin silicone shields that are available currently, and these differences may affect both the infant's extraction of milk and the degree of breast stimulation for the mother.

In the more recent clinical literature, authors have reported specific indications and case studies for which nipple shields improved breastfeeding outcomes.⁵⁵⁻⁶¹ One such study, a retrospective chart review, examined nipple shield use for 15 preterm infants during the in-hospital transition from gavage to oral feedings.⁵⁶ The findings revealed that 9 of the 15 infants consumed 50% or more of prescribed intake during a first breastfeeding with a nipple shield in place. These investigators did not examine milk transfer without the shield or the relationship between duration of shield use and total duration of breastfeeding.

Thus, the small, ultrathin, silicone nipple shield may facilitate milk transfer for the preterm infant during transition from gavage to breastfeeding. Unlike the term, exclusively breastfed infants studied in previous reports, preterm infants seldom consume adequate volumes of milk at breast as they make this transition.⁴⁰⁻⁴⁴ Thus, shield use may actually increase milk transfer and prolong duration of breastfeeding for this vulnerable population.

Method

This study is a retrospective analysis of data for 34 preterm infants who were hospitalized in one of two large teaching hospitals during a 12-month period in 1997-1998. Infants and their mothers were participants in separate, externally funded controlled clinical trials at the two institutions; both trials focused on providing research-based breastfeeding interventions for preterm infants.^{37,62} Both studies involved randomization of an intervention. In one institution, this intervention was the use of advanced practice nurses to provide research-based breastfeeding services; in the other, the intervention was mothers' in-home measurement of milk intake during breastfeeding. To eliminate extraneous variables, only infants and mothers who were randomized to the intervention group for each study were included in the analysis of these data.

Although neither clinical trial focused specifically on the use of nipple shields, these devices were introduced by advanced practice nurses who provided breastfeeding services using the same research-based study protocols. Specific indications (e.g., breast anatomy, slipping off the nipple) for shield use were documented in study records, but for all infants, the shields were introduced because advanced practice nurses felt they would increase the volume of milk consumed by preterm infants during breastfeeding.

Data were collected from standardized data collection forms used in the larger clinical trials. For each infant, volume of intake was compared for two consecutive breastfeedings: the first feeding for which the nipple shield was used and the feeding immediately prior to this first feeding. Only one pair of breastfeedings was compared for each infant because once the shield was introduced and determined to be effective in increasing milk transfer, it was not discontinued for study purposes. The comparison of milk intake for two consecutive breastfeedings is identical to the procedures used in previous studies of the nipple shield. However, in our study, volume of intake during serial breastfeedings with the shield and the techniques used by mothers to discontinue its use in the postdischarge period were recorded and will be reported in a separate article.

Volume of intake had been measured for all breastfeedings by infant test-weights with the BabyWeigh scale (Medela, Inc., McHenry, IL). This technique,

Table 1. Characteristics of the Sample (N=34)

Characteristic	Mean \pm SD	Range
Birth weight, g	1702 \pm 521	770-2820
Weight at first breastfeeding, g	1782 \pm 403	1080-2820
Gestational age at birth, wk	31.9 \pm 3.0	25-37
	n	%
Multiple gestation	14	41.2
Small for gestational age	6	17.6
Male	16	41.7
Ethnicity		
White, non-Hispanic	24	70.6
African American	7	20.6
Hispanic	1	2.9
Other	2	5.9

which has excellent concurrent validity,^{63,64} was performed for all in-hospital and in-home breastfeedings as a part of both study protocols. Other measures that were recorded for all infants included descriptive indications for nipple shield use, number of days that the shield was used as a breastfeeding aid, and total duration of breastfeeding as measured from birth until the mother ceased feeding at breast and/or expressing milk, up to a maximum of 365 days.

Data were analyzed using descriptive statistics to report indications for nipple shield use, duration of nipple shield use, and duration of total breastfeeding. Paired *t*-test analysis was used to compare mean milk transfer with and without the nipple shield. Means for the duration of nipple shield use and total breastfeeding duration were compared by Student's *t* test between two groups of infants: those who demonstrated some milk transfer without the nipple shield and those who did not. Pearson correlation coefficients were used to determine the association between duration of nipple shield use and duration of total breastfeeding.

Results

Sample

The sample consisted of 14 infants from one clinical trial and 20 infants from the other trial. These infants represent 30% and 27%, respectively, of the total number of infants enrolled in the two clinical trials at the time of this retrospective analysis. Characteristics of the sample of 34 infants for which nipple shield use was introduced are summarized in Table 1. The median number of breastfeeding attempts prior to the introduction of the nipple shield was 4, with minimum and maximum numbers of 1 and 10, respectively.

Table 2. Milk Transfer With and Without Nipple Shield Use (N=34)

Characteristic	Mean \pm SD	Range
Milk transfer without shield, ml	3.9 \pm 7.0	0-30
Milk transfer with shield, ml	18.4 \pm 13.2	2-62
Increase in milk transfer with shield, ml	14.4* \pm 9.1	2-41

**t*=9.25, *P*=.0001, paired *t* test

Indications for Nipple Shield Use

For 21 infants (61.8%), nipple shields were introduced to assist with "poor latch" of the infant to the maternal nipple. This category included the specific indicators of the infant "slipping off the nipple" during pauses in sucking and anatomical problems such as a large or flat maternal nipple that made it difficult for the infant to achieve and/or sustain an effective breastfeeding position.

For 10 infants (29.4%), nipple shields were used to correct infants' "falling asleep" within minutes of being positioned at the breast. For this indication, infants had been awake prior to the feeding, grasped the maternal nipple, and fell asleep almost immediately, without further sucking. In these instances, the nipple shield facilitated longer sucking bursts and periods of wakefulness.

The remaining 3 (8.8%) instances of nipple shield use were recorded as "other" and were related to maternal nipple discomfort. Two of the 3 cases were twins of one mother, who complained of extreme nipple sensitivity that could not be attributed to any underlying pathology or improper positioning.

Milk Transfer With and Without the Shield

A paired *t* test revealed that mean milk intake was significantly greater for the feeding with the shield than for the previous breastfeeding without the shield (18.4 ml vs. 3.9 ml; *t*=9.25, *P*=.0001). Furthermore, all 34 infants consumed more milk when the shield was used, with a mean increase of 14.4 ml over the previous feeding without the shield. These data are summarized in Table 2.

To determine whether the ability to transfer milk without the shield influenced the quantity of milk consumed with the shield, we divided the 34 infants into two groups: those who had demonstrated some milk transfer (MT) (*n*=18) for the feeding without the shield and those who had not (NOMT) (*n*=16). No statistically significant differences between the groups were noted for weight and maturity, either at birth or at the time of the first breastfeeding. Similarly, no statistical associa-

tion between MT and NO MT groups and the initial indication for shield use was noted ($X^2=1.87$, $P=.393$).

Mean volume of milk transferred with the shield was significantly greater for the MT group compared to the NO MT group (23.3 ml vs. 12.8 ml; $t=2.48$, $P=.02$). However, the increase in milk transfer with the shield was similar for the two groups (15.8 ml vs. 12.8 ml; $t=0.97$, $P=.34$), suggesting that shield use may be equally effective in increasing milk transfer for both groups of infants.

Duration of Breastfeeding and Nipple Shield Use

Mean duration of breastfeeding for the 34 infants was 169 days (range = 14-365), and mean duration of nipple shield use was 33 days (range = 2-171). A Pearson correlation coefficient revealed no statistically significant association between these variables ($r=.1206$, $P=.50$), indicating that longer nipple shield use was not associated with a shortened duration of breastfeeding.

However, a trend toward an association between duration of nipple shield use and duration of total breastfeeding was noted when these variables were compared for MT and NO MT infants. Although not statistically significant, mean duration of shield use was longer for the NO MT than for the MT group (44 days vs. 22 days; $t=1.46$, $P=.15$). However, longer nipple shield use did not shorten total breastfeeding duration for the NO MT group. NO MT infants were breastfed for a longer time than the MT group (205 days vs. 138 days; $t=1.67$, $P=.11$); however, this difference was not statistically significant.

Additional analyses revealed that mothers in our study used the nipple shield for a mean of 24.3% (0.6%-100%) of the total breastfeeding experience. No statistical association was noted between percentage of time the shield was used and total duration of breastfeeding ($r=-.2890$, $P=.10$).

Discussion

The findings from this study are the first to suggest that use of the nipple shield increases milk transfer and does not shorten total breastfeeding duration. Although our results differ from those of previous controlled trials in which milk transfer was less for breastfeedings with the nipple shield, they are consistent with more recent case reports in the clinical literature. There are two plausible explanations for these differences: the types of infants who served as participants in the studies and design distinctions between the older latex shields and

the newer silicone models used in our research and the case reports.

The preterm infants in our study and the term and preterm infants in recent case reports⁵⁵⁻⁶¹ did not consume adequate volumes of milk during breastfeeding prior to the use of nipple shields. In contrast, the infants who served as participants in the previous controlled trials⁵²⁻⁵⁴ were selected because they had established adequate milk transfer with breastfeeding before the one-time latex nipple shield intervention. These findings suggest that while nipple shields are not indicated for infants who breastfeed effectively, they facilitate milk intake and prolong breastfeeding for infants who demonstrate specific breastfeeding problems. In our research and the published case studies,⁵¹⁻⁵⁴ nipple shields were used temporarily to sustain breastfeeding while specific underlying lactation problems were identified and corrected.

Indications for Nipple Shield Use

In our study, more than 90% of nipple shields were initiated for two indications: infants' not achieving and/or maintaining effective attachment to the maternal nipple and infants' falling asleep within minutes of being placed at the breast. Although not unique to preterm infants, these breastfeeding behaviors probably result from weak intraoral suction (negative) pressures.

Ultrasonographic studies have demonstrated that during breastfeeding, the maternal nipple extends approximately twice its resting length due to infant intraoral suction pressures.⁶⁵ This nipple position is essential for adequate milk intake because the lactiferous sinuses are compressed—squeezing milk into the infant's oral cavity—as the mandible closes during the expression phase (positive pressure) of the suck. However, other work has demonstrated that intraoral suction is maturationally dependent and appears to develop more slowly than comparable expression pressures for preterm infants.⁶⁶

Weak intraoral suction pressures compromise the preterm infant's ability to elongate and maintain attachment to the maternal nipple. Then, during the subsequent expression phase of the suck, the infant closes the mandible over nipple tissue rather than the lactiferous sinuses. If the maternal nipple is especially large or flat, the preterm infant slips off of the breast completely as the mandible closes. These ineffective breastfeeding mechanics compromise the sustained sucking needed

for optimal stimulation of milk synthesis and ejection, restricting milk flow to the infant.

Several characteristics of the nipple shield appear to compensate for weak intraoral suction pressures, and these hypotheses are currently under investigation by our research team. First, the shield creates a nipple shape in the infant's mouth, allowing the infant to extract milk by use of expression with minimal suction, improving milk ejection and transfer. This stable nipple shape is maintained even during pauses in sucking bursts so the infant remains attached to the nipple rather than slipping off. Second, once the shield is placed properly over the nipple and the infant begins to suck, negative pressure appears to be generated in the small chamber between the tip of the maternal nipple and the interior of the shield. These pressures may compensate for weak infant suction and facilitate accumulation of milk in the shield during pauses in sucking, making it available to the infant immediately when sucking resumes. We speculate that the continuous availability of milk in the shield chamber explains its effectiveness for infants who cease sucking almost immediately upon being placed at breast. A large body of previous research has demonstrated that infants modify the sucking pattern based on the availability and flow of nutrient.⁶⁷

Effect of the Nipple Shield on Milk Transfer

Our findings indicate that the nipple shield increased milk transfer for all of the 34 infants studied, independent of whether the infant had consumed measurable volumes of milk during breastfeedings without the shield. This increase in mean milk transfer when the shield was used (18.4 ml vs. 3.9 ml without the shield) was statistically and clinically significant. Greater milk intake at the breast with the shield minimizes the need for complementary feedings away from the breast when the mother is present.

However, the clinician should consider several factors in applying these findings to the practice setting. First, the shield will not correct milk transfer problems if the mother has an inadequate milk volume. Second, although the presence of milk in the shield and sustained infant sucking bursts are suggestive of milk intake, the only accurate clinical evaluation of milk transfer is infant test weighing procedures,^{63,64} as were used in our study. These serial measures provide important information for mothers and practitioners, especially as the shield is introduced and when mothers begin to discontinue its use in the postdischarge period.

Effect of the Nipple Shield on Duration of Breastfeeding

Although no longitudinal controlled trials have been reported, it is widely assumed that use of the nipple shield decreases breast stimulation, which adversely affects prolactin and oxytocin responses. Over time, suboptimal concentrations of these lactation hormones would lead to reduced milk yield and early, unplanned weaning. However, the findings from our study and previously published case reports do not support this theory. For mothers whose infants suck only briefly before slipping off the breast or falling asleep, use of the shield increases rather than reduces breast stimulation. All 34 mothers reported that they felt "stronger sucking" and more rapid milk ejection for feedings with the nipple shield. These maternal impressions are consistent with our explanation for the mechanics of milk transfer with the nipple shield. Also, it is probable that mothers felt more relaxed and confident as they witnessed greater infant milk intake with the shield, a response that theoretically mediates the prolactin-inhibiting factor, optimizing prolactin release and milk synthesis. However, this hypothesis was not tested in our research.

Our data indicate that mothers of preterm infants used the nipple shield for a mean of 32.5 days, a figure that coincides with these infants' achieving term, corrected age. This finding is consistent with previously published international studies suggesting that infant maturity is a major determinant of adequate milk transfer during breastfeeding for this population.^{40-44,68-73}

The mean duration of breastfeeding for this vulnerable population was 169.4 days, which exceeds published statistics for low-risk infants and mothers in the United States.³⁷⁻³⁹ In contrast to widely accepted assumptions, our data revealed no inverse relationship between the duration of nipple shield use and the total duration of breastfeeding. This finding was underscored when these variables were examined for the MT and NO MT infants. Although NO MT infants used the nipple shield nearly twice as long as the remaining MT infants did (43.5 days vs. 22.2 days), mean duration of breastfeeding was 66.4 days longer for the NO MT infants.

These findings have important implications for clinicians who advise these mothers about nipple shield use during the early post-NICU period. Because of unfounded concerns about nipple shields, mothers are frequently instructed to discontinue use of the shield much sooner than did the women in our study. Premature discontinuation of the shield predisposes the infant

to inadequate milk intake and compromises the mother's milk yield. The findings from our study and published case reports clearly demonstrate that women can use the nipple shield for significantly longer time periods than previously thought appropriate. Additional longitudinal data from our study, focusing on milk transfer during the postdischarge period, and specific clinical implications for monitoring of long-term shield use will be reported separately.

Summary and Conclusions

Although our findings indicate that the nipple shield increases milk transfer and duration of breastfeeding for preterm infants, lactation proponents often object to its use because of philosophical—rather than scientific—concerns. Among these concerns: the shield is “like a bottle,” it places an artificial barrier between the infant and the breast, and its use supports an industry that capitalizes on making breastfeeding “unnatural.” These philosophical objections have led to recommendations that preterm infants receive their mothers' expressed milk by alternative methods, such as cup and finger feedings, until complete breastfeeding is achievable.^{74,75} However, it is important to recognize that the safety and efficacy of these methods have not been studied systematically in controlled trials. Similarly, breastfeeding outcomes and maternal acceptance have not been compared for nipple shields and alternative devices. These issues warrant scientific examination because alternative feeding methods necessitate that the mother express milk with a breast pump and feed her baby away from the breast. In contrast, the nipple shield allows a mother to feed at the breast while minimizing the total time required for infant feeding.

Subsequent research should focus on reconceptualizing the nipple shield as a temporary milk transfer device for preterm infants. Because the nipple shield was designed to minimize maternal discomfort, no previous studies have examined the relative pressures between the shield chamber and the infant's oral cavity to determine the exact mechanism by which milk transfer is facilitated. It is probable that currently available nipple shields can be improved when the primary function for these devices is to increase milk intake rather than treat nipple discomfort.

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Resumen

Estudios internacionales sugieren que los niños prematuros son vulnerables a consumir poca cantidad de leche cuando son amamantados al pecho hasta alcanzar el término, edad corregida. Teniendo altas hospitalarias tempranas, es necesario tener estrategias para mantener la lactancia durante el tiempo de transición en que estos niños pasan a ser amamantados exclusivamente al pecho. El propósito de este estudio es un reporte de re-

sultados de 34 niños prematuros con una media de peso al nacer y edad gestacional de 1702.3 g (770-2820) y 31.9 semanas (25-37), respectivamente, cuyas madres utilizaron pezoneras de silicona ultra delgada para aumentar la transferencia de leche. Las medias de transferencia de leche se compararon en dos amamantadas consecutivas con y sin pezonera. La duración total de la lactancia se calculó con base a los datos de las historias clínicas del proyecto, con un máximo de 365 días. La media de transferencia de leche fué significativamente mayor en los episodios con pezonera (3.9 m vs. 18.4 ml), demostrando que los 34 niños ingirieron más leche con la pezonera. La duración media de uso de pezonera fué de 32.5 días (2-171), y la media de duración de la lactancia fué de 169.4 días (14-365); no se observó asociación entre estas dos variables. Se utilizó la pezonera en 24.3% del total de las amamantadas (0.6-100%), no se observó una asociación significativa entre el porcentaje del tiempo del uso de la pezonera y la duración total de la lactancia. Estos hallazgos son los primeros en indicar que el uso de la pezonera aumenta el consumo de leche sin disminuir la duración total de la lactancia en niños prematuros.