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Research Report 2021---03

Sucking research : **Sucking**

Research on the infant sucking behavior and the change of nipple shapes in the oral cavity during sucking

Softness that reproduces natural sucking behavior

Breastfeeding support statement

Through appropriate information, products, and services,
we support breastfeeding for as long as mother and child wish.

In cases where breastfeeding is difficult, for whatever reason,
we offer a full range of products and solutions for healthy child development.

Pigeon Corporation

Address 4-4, Nihonbashi Hisamatsu-cho, Chuo-ku, Tokyo 103-8480, Japan (Head Office)
Tel+81-3-3661-4200

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Research on the infant sucking behavior and the change of nipple shapes in the oral cavity during sucking
Softness that reproduces natural sucking behavior

A softer nipple of a mother is considered better for appropriate infant sucking behavior[1]. Although the nipple softness has been assessed by palpation in the past[2)3)], there were few objectively measured and quantified data. Thus, Pigeon has developed a new measuring device and conducted research on the "nipple softness of breastfeeding women," which is important for the natural sucking behavior[4)5)] based on objective measurements.

Pigeon's research on sucking

Abstract of "Measurement of nipple softness of breastfeeding women 3 —Comparison of softness of nipples and lips—"[6)]

Pigeon has developed a new measuring device and tried to quantitatively assess nipple softness of breastfeeding women. The previous research[4)5)] indicated that the measured values of nipple elasticity could be objective assessment indicators for the nipple softness of breastfeeding women. In this research, we measured the nipples of breastfeeding women using a small-sized device considering the practical use in sucking support settings. As a result, it was confirmed that the values of nipple elasticity of breastfeeding women could be stably measured with the small-sized device (median: 0.11 N at a pinching ratio of 25%; median: 0.77 N at a pinching ratio of 50%). In actual breastfeeding support settings, "lip-like" softness is used as an indicator of appropriate nipple softness. We measured the lip elasticity values for comparison. They showed similar values and characteristics of reaction force change to nipple elasticity. Thus, lip-like softness was considered appropriate as an indicator of the nipple softness by palpation.

Fuka Uchikoshi*1), Satoru Saito*1) *1) Central Laboratory

Background of the research

- **Mechanism of sucking behavior and sucking**
  During sucking, infants make a completely different mouth movement from that of adults made at the time of sucking a liquid with a straw. The results of observational research by intraoral videography[7)] and ultrasonic tomography[8)] have revealed that milk is squeezed out by the coordinated movement of the lips, tongue, and jaw that stimulate, compress, and expand the nipple. This action of compressing and expanding the nipple is mainly performed by the tongue movement, and this is considered to be the central mechanism of the "sucking" behavior that exists only in infancy[9)].

- **Assessment of the nipple softness of breastfeeding women**
  When sucking, infants need to properly latch on nipples to effectively drink milk. The condition of the mothers' nipples is considered to have an effect on latching on. It is pointed out that nipple softness (hardness of nipples) and nipple length are involved in the success of breastfeeding and the occurrence of troubles[3)]. And a softer nipple is considered better for appropriate sucking[1)]. However, the hardness of the nipple has been subjectively assessed by palpation such as observing the extension level of nipples by pinching[2)] and classifying the hardness into 3 levels using the tactile sense[3)]. Thus, the objective assessment method that quantifies the measurements into numbers has been required.

- **Effect of nipple softness on sucking behavior**
  In sucking behavior, "compressing" and "expanding" the nipples are repeated. It is known that the "wave-like movement" of the tongue is the basis for these series of movements[10)] (Figure 1). The smooth movement of an infant's tongue compresses and expands the mother's nipple and thus milk is drawn. According to intraoral ultrasound observation research during direct breastfeeding, the tongue movement of infants changes according to the softness of the mothers' nipples and artificial nipples[10)11)] (Figure 2).

Objective of the research

In this research, we obtained the measurements of nipple softness of breastfeeding women with a small-sized measuring device. We aimed to compare and examine these results with the "lip softness" which has been previously used as an indicator of sufficiently soft nipple for the assessment by palpation.

Figure 1 Oral cavity during sucking

The nipple is placed in the sucking fossa, and the tongue, hard palate, sucking fossa, lips, and areola are closely attached to the nipple to create a sealed condition[10)]. It has been found that creating a sealing space in the oral cavity through proper latching on is important for effective milk transfer.

●Cross-section of the oral cavity during direct breastfeeding

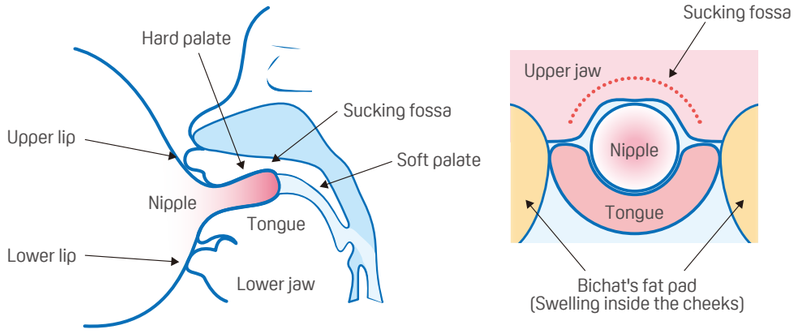
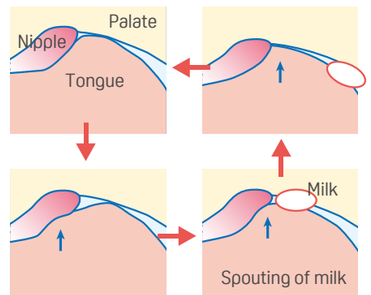
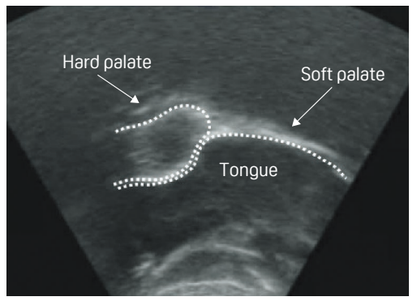


Figure 2 Tongue movement during sucking : Wave-like movement

The wave-like movement of the tongue is characterized as below through the observational research by intraoral ultrasonography.

●Characteristics of peristaltic-like movement[7)12)13)]





❶ The position of the tongue remains unchanged but the surface becomes wavy.
❷ The bump at the tip of the tongue moves to the root of the tongue.
❸ The wave-like motion is repeated. (cycle = about 0.8 seconds)
❹ Milk is sucked (or squeezed out) by compressing and expanding the nipple.

The wave-like movement (Ishimaru, 2000)[11)] was partially modified.

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Methods

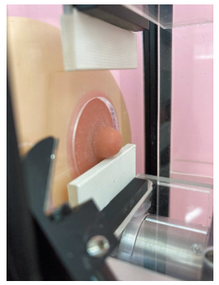
Subjects

Measurement of the nipple softness :
25 mothers who were directly breastfeeding their infants aged up to 15 weeks without problems (requesting them to measure immediately before breastfeeding)
Measurement of the lip softness :
10 women in the same age group who gave consent to this research

Measurement method

Measuring device:
Nipple softness measuring device (jointly developed with Tec Gihan Co., Ltd.)
Measuring procedure:
(1) Measure the diameter at 5 mm from the tip of the nipple with a caliper.
(2) Make the setting of push up to 50% of the nipple diameter on the software.
(3) Insert the nipple into the plate of the measuring device in the sitting position, and get it captured at a speed of 4 mm/sec. Measure the reaction force to the push using a pressure sensor. Measurement was performed at least 10 times in succession (taking images around the sensor). For comparison, the elasticity was measured when the portion of 5 mm from the tip of the lip was pushed up to 50% of the diameter.

●Nipple softness measuring device



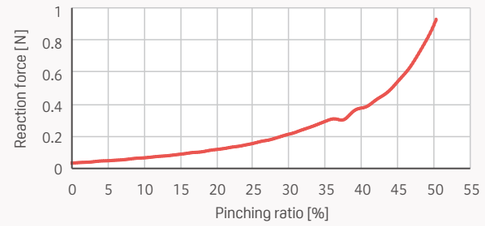
Definition of nipple elasticity [4]

According to the research on the change of nipple shapes during direct breastfeeding, the portion of 5 mm from the tip of the nipple was most compressed and changed up to about 50% at the time of sucking[14]. Based on the result, the measurement site is set at 5 mm from the tip of the nipple, and the magnitude of the reaction force (N) to the pinching ratio (%) of the nipple diameter is defined as "nipple elasticity."

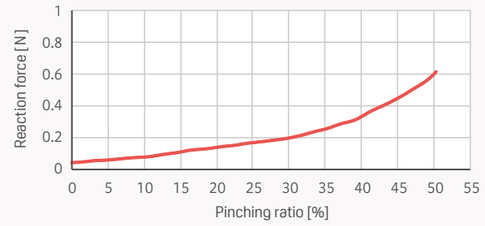
Results

- Measurement data of 21 subjects were analyzed after excluding 4 subjects who breastfed immediately before measurement.
- Nipple elasticity of breastfeeding women was measured by the small-sized "Nipple softness measuring device," and median values at the pinching ratio of 25% and 50% were 0.11 N (0.01 N-0.57 N) and 0.77 N (0.14 N-3.09 N), respectively.
- Lip elasticity was measured for comparison by the small "Nipple softness measuring device," and median values at the pinching ratio of 25% and 50% were 0.14 N (0.02 N-0.42 N) and 0.59 N (0.15 N-1.29 N), respectively.
- Both elasticity values showed a nonlinear change to the pinching ratio as shown in the figure below.

●Nipple elasticity in breastfeeding women



●Lip elasticity



These results suggested:
Nipple softness can be quantified by the small-sized measuring device.

Discussion of research results

Possibility of quantitative indicators of the nipple softness using the small-sized measuring device

We performed measurement in this research using a measuring device developed by improving and miniaturizing the measuring device used in the previous research[4][5]. The nipple elasticity values (at 50% pinching ratio) were similar to the nipple elasticity values (0.74N[4], 0.96N[5]) obtained in the previous research, and a similar nonlinear change was observed. Based on the results, we confirmed a certain level of usefulness of the "Nipple softness measuring device" - a small-sized measuring device used in this research.
Also, lip elasticity values were similar to nipple elasticity values and were suggested to be valid as the standard for nipple softness by palpation. Both the nipple and lips showed a nonlinear change in elastic values, which was considered to be a characteristic of softness common to both sites.
The device used in this research quantified the nipple softness which was previously assessed mainly by palpation. We expect these values will be deployed into research in which they are examined as objective indicators.

PICK UP PIGEON's research

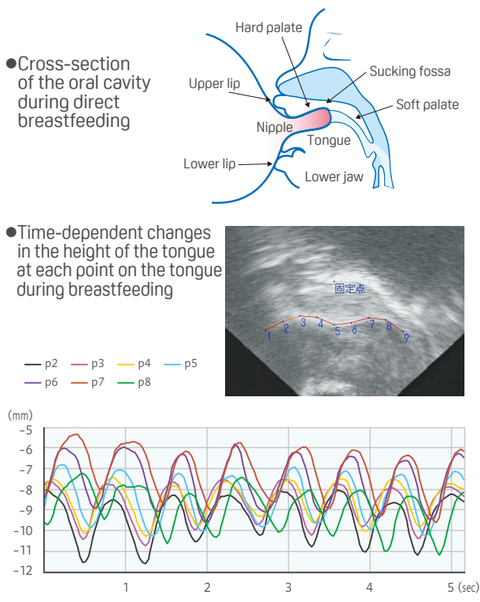
Ingenious "softness that reproduces natural sucking behavior"

Various findings obtained in previous research focusing on sucking are used in the development of Pigeon's artificial nipple "SofTouch Series (feeling breastfeeding)." Let us introduce some of them.

Sucking by the "wave-like movement" of the tongue

We observed the movement of the tongue during sucking by ultrasonography and analyzed the results using the two-dimensional motion analysis system. We found that the height of the tongue at each point on the tongue changed over time and sucking was performed by the smooth, wave wave-like movement of the tongue[10] (Figure 3).

Figure 3 Movement of the tongue during sucking

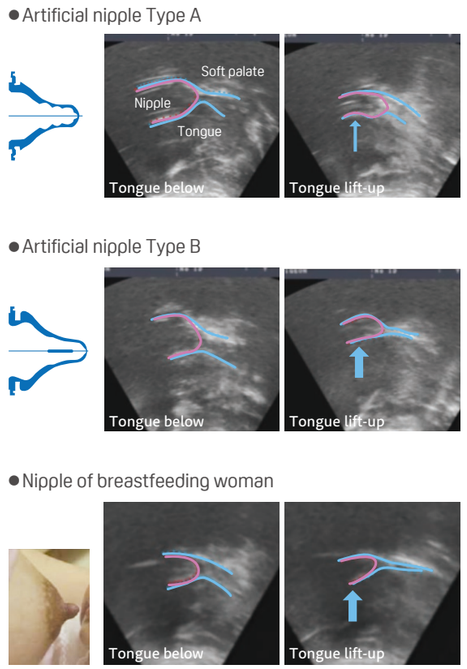


2002 Ishimaru: Morphological changes of the tongue and nipple during sucking - Smoothness of the tongue movement - Child Health v5n10p53

Change in the shapes of mothers' nipples and artificial nipples caused by the tongue movement during sucking[14]

The change of nipple shapes was observed during sucking by intraoral ultrasonography. The results have revealed that the nipple was compressed to about 6 mm by the tongue movement of infants during direct breastfeeding. When we examined the compression rate at different positions from the tip of the nipple (Figure 4), the compression rate was the largest of 55% at the position of 5 mm from the tip of the nipple.
On the other hand, the compression rate of the artificial nipples tended to differ depending on their hardness and shapes. We compared two types of artificial nipples (Type A: A spherical nipple, Type B: A straight type without a spherical shape of the nipple; thicker and softer silicone material is used for Type B compared with Type A). It was hard to compress the tip of the nipple of Type A while Type B was found to be compressed similar to direct breastfeeding.

Figure 4 Change of the shapes of nipples of breastfeeding woman and artificial nipples caused by the tongue movement during sucking



Combination of direct breastfeeding and bottle feeding

Pigeon's artificial nipples reflect various functions of the sucking behavior found in the sucking research we have introduced. Based on the sucking research, we are reproducing the shape and softness function that allow the same compression as the nipples of breastfeeding women and do not disturb the infant's tongue movement. Research conducted in Russia has reported that less newborn infants rejected breastfeeding after using Pigeon's artificial nipple "SofTouch Series" and smoothly returned to direct breastfeeding[15] (Figure 5). This suggests that the use of SofTouch Series can reduce nipple confusion and it can be used in combination with direct breastfeeding.
SofTouch Series is not developed by tracing the shape of the mother's breast. It is designed to reproduce the function of the infant's natural sucking behavior.. We try to reproduce the nipple softness aiming at the nipple elasticity values of breastfeeding women. We have adopted the shape in which the tip of the nipple is compressed instead of remaining uncompressed. Peristaltic PLUS Series is characterized by "softness that reproduces the natural sucking behavior."

Figure 5 Status of breastfeeding rejection and sucking after the use of "SofTouch Series"

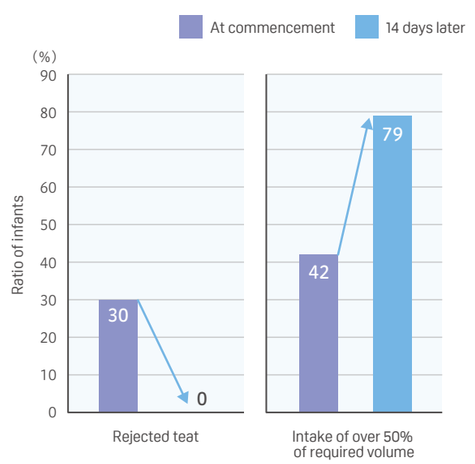


Figure prepared based on Reference[15]

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