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Original research

Analysis of tongue movements during sucking by infants with cleft lip and palate using a diagnostic ultrasound device: Changes during the six months after birth

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ABSTRACT

Objective: The aim of this study was to examine how bottle feeding movements improved as a result of the fitting of Hotz's plates in infants with cleft lip and palate, with a focus on tongue movements.

Materials and methods: The subjects were 11 infants with cleft lip and palate (CLP infants) and 16 healthy infants, and their sucking movements were observed by diagnostic ultrasound in B/M mode. Measurements were made by placing the echo window beneath the infant's jaw and visualizing frontal and sagittal images of the tongue during sucking movements. Tongue movements during sucking by CLP infants with and without Hotz's plates were compared with those of healthy infants in each of the three groups. A *t*-test was used to compare values with and without Hotz's plates, a Mann–Whitney *U*-test was used to compare measurements between CLP and healthy infants, and a Kruskal–Wallis test was used to investigate changes in tongue movements with increasing age.

Results and conclusion: The results showed that tongue movements during bottle feeding were larger in CLP infants without Hotz's plates than in CLP infants with Hotz's plates and healthy infants, indicating an unphysiological condition in CLP infants without Hotz's plates. When Hotz's plates were fitted, movements were stable and close to those of healthy infants, suggesting that fitting Hotz's plates is useful.

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1. Objective

Cleft lip and palate (CLP) is one of the most common external deformities in Japan. Its incidence differs markedly among different racial groups, and it is more frequent among Japanese than any other group worldwide, occurring in 1 in 500 people [1]. This disability is extremely multifaceted, depending on the type of cleft and the severity and location of cleavage. In particular, incomplete closure of the anterior oral cavity due to cleft lip and insufficient negative pressure formation in the mouth during bottle feeding and swallowing due to cleft palate may cause functional difficulties in feeding. Physical growth and development are therefore often

delayed in infants with cleft lip and palate due to difficulty feeding. This also causes inestimable anxiety and psychological pressure for their parents. Hotz's plates [2–4] were devised as a resin appliance capable of closing the fissure, with the aim of improving bottle feeding difficulties and inducing jaw growth in children with cleft palate. Fitting with Hotz's plates is believed to increase milk flow, increase sucking pressure, and enable ridge formation [5–8].

Oral function and swallowing movements in particular in infants with cleft palate have previously been addressed in studies by Mckee [9], Shelton [10], and Sakuda et al. [11], but subsequent investigation of this subject has been insufficient. There have also been few studies of tongue movements by infants with cleft palate during bottle feeding, with the only reports being those of Takano et al. [12] and Haishima et al. [13]. Arakaki et al. [14] also reported that the action of Hotz's plates and other oral appliances promoted morphological and functional growth and development of the mouth. However, none of these studies evaluated oral function sufficiently, particularly in terms of dynamic evaluation of the tongue. The effects of Hotz's plates were investigated by focusing on tongue movements during sucking in CLP infants.

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Fig. 1. Recording situation.

2. Subjects

The subjects were 11 infants with cleft lip and palate (CLP infants) (5 boys, 6 girls; age, 2–24 weeks after birth, average gestation, 37.8 ± 2.8 weeks) who underwent multidisciplinary treatment for cleft lip and palate in the Department of Dentistry and Oral Surgery of the University of the Ryukyus Hospital and who were able to be fitted continuously with a Hotz's plate. A control group of healthy infants included 16 volunteer children with no stomatognathic abnormalities (7 boys, 9 girls; age, 2–24 weeks after birth; average gestation, 38.0 ± 1.8 weeks). Infants with moderate or severe congenital disease and those with a history of difficulty feeding were excluded from the study (Table 1).

The measurement period lasted from 2 weeks until 6 months after birth, spanning the period during which cheiloplasty was performed, and measurements were made at bimonthly intervals.

CLP infants and healthy infants were divided into three groups: Stage I, 1–2 months; Stage II, 3–4 months; and Stage III, 5–6 months.

3. Methods

Measurements were made while the infant was held horizontally on the mother's or guardian's lap and bottle-fed (Fig. 1). Infants were fed either the formula milk to which they were accustomed or expressed breast milk. The bottles and nipples normally used by the subjects were used. The diagnostic ultrasound (US) device used for measurements was a LOGIQ BOOK XP (GE Healthcare Japan, Tokyo, Japan). Ultrasound images were visualized with a micro-convex probe (GE Healthcare Japan) held in the investigator's hand. Tongue movements during sucking were visualized after the subject had started feeding and regular sucking movements were observed.

A single investigator carried out the US visualization of tongue movements during sucking in CLP infants and healthy infants.

3.1. Analysis of ultrasound images

Tongue movements during sucking were visualized by US in the frontal and sagittal orientations, and analysis in the sagittal plane was carried out for the front and posterior of the tongue.

3.1.1. Frontal plane

Tongue movement in the frontal plane was measured using the method of Otsuka et al. [15]. The probe was positioned under the subject's jaw so that the alveolar ridge corresponding to the position of the bilateral deciduous molars could be visualized tomographically in the frontal plane, and measurements were taken with

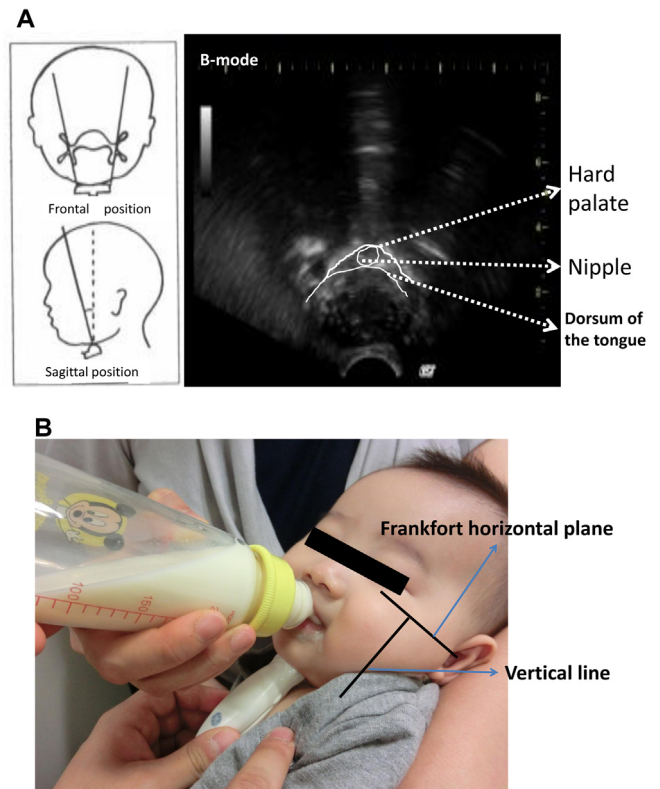


Fig. 2. (A) The movement of the dorsum of the tongue in the frontal plane. Imaging of the section connecting the sides of the lower jawbone and corresponding upper maxillary alveolar process is performed in an angle slightly tipped forward, as suggested by Otsuka et al. [15]. (B) Probe position.

it tipped slightly forward [15]. A line passing through the center of the dorsum of the tongue was used as a baseline, the distance moved by the dorsum of the tongue during sucking was measured in M-mode, and the difference in the distance moved by the center of the tongue was calculated (Figs. 2 and 3).

3.1.2. Sagittal plane

3.1.2.1. *Front of the tongue.* Movement of the anterior part of the tongue in the sagittal plane was measured using the method of

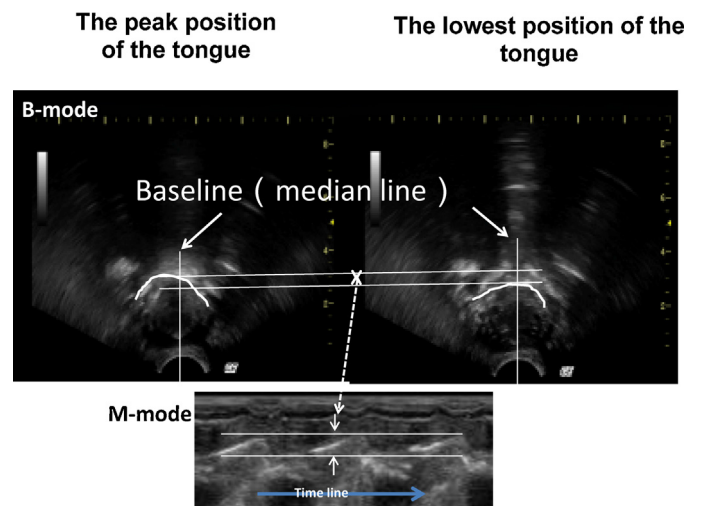


Fig. 3. Measurement of the dorsum of the tongue in the frontal plane. The median septum is regarded as the baseline to measure the differences in the movement distance. In this way, images of the central position of the tongue can be obtained.

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