

Fingernail for the Physiological Indicator of Fluoride Exposure in Korean Children

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Abstract

This work was based on the hypotheses that fingernail clippings can be used as a biomarker for the subchronic exposure to fluoride. This study was conducted to prove the hypotheses and fingernail clippings were collected from 120 preschool children aged 3~6 residing in Jumunjin (community water fluoridation area) and Kangnung (non-fluoridation area). The acid-diffusible fluoride in the fingernail clipping was isolated by the acid-diffusion technique and measured with a fluoride electrode. The mean fingernail fluoride as the children's living area were 4.49ug/g (SD 2.43) to Jumunjin and 2.68ug/g (SD 1.13) to Kangnung. As would be expected, the fluoride concentration in fingernail clippings were significantly different between the two geographical groups ($p < 0.001$) determined by t-test.

Introduction

The generally accepted indicators of fluoride utilization, urine and plasma fluoride measurements, fell short of our requirements for two reasons: both indicate fluoride utilization in the short-term and plasma fluoride determination involves the collection of blood, which can impose difficulties in dental surveys.

Fingernails have been analyzed to estimate industrial and environmental exposures to a wide variety of inorganic ions such as metallic elements which used to be accumulated in hard tissue. Therefore fingernails are possible biomarker for the exposure to and body burden of fluoride in humans. Recently the possible use of nails as indicators of subchronic exposures to fluoride. Concerns about the reliability of nails as biomarkers included the possibility of contamination due to uptake of fluoride from water and other exogenous sources, questions about appropriate preparative and analytical procedures, and the wide range of fluoride concentrations found in the literature.

The aim of the present study were to determine the possibility of using fingernail fluoride concentrations to estimate the daily fluoride exposure. And determine the effects of several variables on human fingernail fluoride concentrations including: (1) analytical method for detection of fluoride concentration in fingernails (2) comparing the concentration of fingernail fluoride of children residing

in fluoridated community with that of children residing in non-fluoridated community (3) assess the possibility of using the fingernail clippings as a biomarker for the subchronic exposure to fluoride.

Materials and Method

The two communities in this study from which fingernail clippings were collected were the fluoridated community of Jumunjin and the non-fluoridated community of Kangnung, Kangwondo, Korea. These communities were selected because of their documented fluoride histories; their proximity to one another; and the similarity of their demographic and socioeconomic characteristics. 120 preschool children aged 3~6 were selected for collecting fingernail samples.

Fingernail clippings were weighed and analyzed for fluoride using the hexamethyldisiloxane(HMDS) diffusion method of Taves as modified by Rojas-Sanchez et al. The acid-diffusible fluoride in the fingernail clippings was isolated by the acid-diffusion technique using H₂SO₄-HMDS and trapped by NaOH solution. After trapping by NaOH solution, added 100ul of deionized water and equal volume of Total Ionic Strength Buffer(TISAB II) and measured with a fluoride electrode(Orion Research EA940).

The mean fluoride content, minimum and maximum values, and 95% confidence intervals were determined for each fingernail classification group, and a Student's t-test was used to test for differences between the two communities. A significance level of $\alpha=0.05$ was used to test all hypotheses. Statistical analyses were performed using SAS V6.12.

Results and Discussion

The data of fluoride concentration of fingernail were obtained from 120 children with 60(34 boys, 26girls) residing in Jumunjin and 60(25 boys, 35 girls) in Kangnung. The children participated in this investigation were aged 65.10(SD 11.81) months in Jumunjin and 60.93(SD 10.15) months in Kangnung.

Table 1. Fingernail fluoride concentration of Korean children aged 3-6 years

Classification	Total(N=104)	Jumunjin(N=54)	Kangnung(N=50)	p-value ^b
Age(month) ^a	62.65±11.39	65.15±11.89	59.96±10.31	0.020
Body weight(kg) ^a	19.17±3.38	19.07±3.63	19.27±3.27	0.769
Fluoride concentration(ug/g) ^a	3.62±2.11	4.49±2.43	2.68±1.13	<0.001

^aMean ± standard deviation(SD)

^bStudent's t-test for differences between the two communities

The mean fluoride concentration of children's fingernail clippings are shown in table 1. The mean fingernail fluoride as the children's living area were 4.49ug/g(SD 2.43) to Jumunjin and 2.68ug/g(SD 1.13) to Kangnung. As would be expected, the fluoride concentration in fingernail clippings were significantly different between the two geographical groups($p < 0.001$) determined by t-test. The results suggest that fingernail fluoride concentration could be used as a biomarker for fluoride exposure. Whitford et al. reported that there appears to be no need to mince or file the clippings prior to analysis. These results indicate that the analysis of intact nail clippings by electrode following overnight HMDS-facilitated diffusion quantitatively detects all fluoride in fingernails. The results of the time-course study, during which an additional 3.0mg of fluoride were ingested each day for 30 days, showed a lag time of approximately 3.5 months before the nail fluoride concentrations increased. This finding indicated that fluoride enters fingernails via the matrix and not through the nail bed. It also provides strong support for the systemic circulation as the major source of fingernail fluoride and, therefore, for the hypothesis that nail clippings can be used as a biomarker for subchronic fluoride exposure. Further, it is likely that nail clippings can serve as a suitable biomarker for chronic fluoride exposure provided that fluoride intake remains relatively constant.

Conclusion

This study was conducted to analyze the fluoride in the fingernail clippings and prove the hypotheses that fingernail clippings can be used as a biomarker for the subchronic exposure to fluoride. We determine the fluoride concentration in fingernail of 104 Korean children aged 3~6 years by acid-diffusion technique. The mean fingernail fluoride concentration of children residing in Jumunjin and Kangnung were 4.49ug/g(SD 2.43) and 2.68ug/g(SD 1.13), respectively. In this research, we observed similar results compared to that of previous investigators in other country. It is concluded from this investigation that the amounts of fluoride in fingernail of children living in Jumunjin(fluoridated areas) and Kangnung(non-fluoridated area) were significantly different from each other. Therefore fingernail clippings can be used as a biomarker for fluoride exposure.

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