Sensory Dysfunctions due to Trace Element Deficiencies and the Clinical Aspects
—Taste and olfactory disorders—

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Abstract: Among the trace elements known to be essential to human nutrition, zinc is typical in that the lack of it can cause sensory dysfunctions in human. It is known that a deficiency of zinc results in a wide variety of diseases with sensory (gustatory, olfactory, and visual) dysfunctions being only one type of them. In the present study, the focus is placed on the taste disorders as an example of a sensory dysfunction caused by trace element deficiencies; and on the etiological mechanism of the disorders that are associated with zinc deficiency. A reduced serum zinc level (below $70\mu g/dl$) seen in cases of taste disorders has also been noted frequently in similar conditions that are putatively provoked by other causes (e.g., those caused by systemic or drug-induced dysfunctions). These findings suggest that zinc is likely to play a role in the development of many types of taste disorders. Supplementation by oral zinc preparations has been found to be effective in a number of double-blind tests on clinical cases with idiopathic or zinc deficiency-induced taste disorders, which substantiated the aforementioned possibility.

Key words: Zinc; Taste disorder; Olfactory disorder; Essential trace elements

Introduction

Among the trace elements essential to human nutrition, zinc is typical, the deficiency of which is known to cause sensory dysfunctions. Located at the center of a number of metalloenzymes, it is involved in many types of essential metabolic processes, thus considered to be a very important trace element for the body. It is known that a deficiency of zinc is responsible for a variety of disorders, sensory dysfunctions being one type.

For the sensory dysfunctions, gustatory, olfactory, and visual dysfunctions are known.1)
deficient feed, a taste disorder developed in 30% of the young animals and 70% of their older counterparts. These zinc deficient rats exhibited a decrease of microvilli at the ends of their taste cells where the receptors are located or breakage of these cells with their ends torn off. Many other abnormal features — e.g., a loss of electron dense substance, a reduction in the number of Golgi-originated dark granules that are distributed in the taste cells, and vacuolization of these cells — were also noted. 5) These abnormalities involving the taste bud cells that were confirmed in animal experiments were also observed in human subjects who suffered from taste disorders caused by zinc deficiency. 6)

The taste cells of normal rats continuously undergo a fast turnover (requiring about 10 days) through generation followed by replacement of their epithelial cells to maintain the function as taste receptors. In zinc-deficient rats, however, this turnover time is prolonged: it is known that if the zinc is replaced, this delay in the turnover is corrected, while improving also the symptoms of taste disorder. 7)

### Zinc Deficiency and Taste Disorders

Table 1 lists diverse causes for taste disorders. 2) Some develop as a direct consequence of the dysfunctions of the peripheral or central nervous system related to taste sensation; but many are considered to be caused by dysfunctions at the peripheral receptor level. Taste disorder caused by zinc deficiency belongs to the category of peripheral receptor level dysfunctions.

#### 1. Taste disorder in animal experiments

In the living body, zinc is abundantly distributed in epithelial tissues and their appendages (about 20% in organs, such as the skin, hair, and nails). 1) The lingual epithelium is also known for its rich zinc content. In particular, zinc is localized in many sites at the base of the filiform papillae and the epithelium section, including the taste buds of the vallate papillae. Furthermore, the area within the taste buds (in particular, around the taste pores) is richly endowed with zinc enzymes (e.g., alkaline phosphatase, acid phosphatase, ATPase, adenylate cyclase, and cyclic AMP phosphodiesterase), 3) which suggests a significant correlation between the taste organ and zinc.

Of the rats that have been raised on zinc-deficient feed, a taste disorder developed in 30% of the young animals and 70% of their older counterparts. These zinc deficient rats exhibited a decrease of microvilli at the ends of their taste cells where the receptors are located or breakage of these cells with their ends torn off. Many other abnormal features — e.g., a loss of electron dense substance, a reduction in the number of Golgi-originated dark granules that are distributed in the taste cells, and vacuolization of these cells — were also noted. 5) These abnormalities involving the taste bud cells that were confirmed in animal experiments were also observed in human subjects who suffered from taste disorders caused by zinc deficiency. 6)

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#### 2. Zinc deficiency-induced taste disorder in human

The low serum zinc level (below 70 μg/dl) seen in cases of a taste disorder is also frequently observed in those patients suffering from a similar affliction that is caused by a systemic disease or incurred by drug actions. 8) It is suspected that in many instances of taste
disorders ostensibly from other causes, zinc deficiency is also involved in their etiology. Even those cases of an idiopathic taste disorder that yield normal results in clinical tests (including analysis of serum zinc level), oral zinc administration has been found to be as effective as in those suffering from zinc deficiency. It is suspected that in these cases of idiopathic taste disorders, a latent zinc deficiency that cannot be detected by ordinary serum chemical analyses exists and participates in the development of taste disorder.

For the pathogenesis of zinc deficiency in human, various causes have been put forth; but no organized studies have been conducted on what causes this deficit in patients who ultimately develop a taste disorder. Tomita suggested the low zinc content of the typical Japanese diet and the high intake of processed food that may contain a high content of food additives as the possible causes for the low blood zinc levels among Japanese.

Treatment of Zinc Deficiency-Induced Taste Disorder

1. Zinc preparations used for treatment

Zinc sulfate has been used for a zinc preparation. In most instances, each capsule contains 100 mg of zinc sulfate (equal to 23 mg of zinc) and is administered 3 times a day (300 mg/day). This method is cumbersome because each capsule must be prepared by placing the right amount of zinc sulfate. The only zinc-containing pharmaceutical preparation that can be prescribed is polaprezinc (Promac), a product used to treat peptic ulcers. Its dosage is set at 150 mg/day, which is given twice a day (after morning and evening meals). If the serum zinc level does not rise sufficiently, it may be administered before meal.

2. Therapeutic effect of zinc preparations on taste disorders

If stratified by the causes of taste disorders, the efficacy of zinc sulfate is 73.7% for a condition caused by zinc deficiency and 75.8% for that of an idiopathic nature. Thus the efficacy rate was about the same in the two disorders of different etiologies. For a taste disorder caused by systemic diseases or drug actions, the efficacy rate is slightly lower (65 to 67%), with an overall efficacy of 67%. Double-blind tests were conducted on the efficacy of zinc preparations on taste disorders by using zinc gluconate and zinc picolinate. Significant efficacy has been reported for those cases with zinc deficiency-induced and idiopathic taste disorders.

Olfactory Disorders

In rats with a zinc deficiency such as that described above, the zinc content in the olfactory epithelium also decreases markedly. The ultrastructure of the olfactory epithelium also undergoes changes: the entire epithelium becomes squamatized, intercellular space markedly increases, and most outstandingly, the olfactory cells undergo extreme degeneration. However, it has been reported that administration of zinc corrects these deformation and induces neurons to regenerate. Reports such as these suggest that zinc deficiency may be one cause for olfactory disorders. At the moment, however, there have not been sufficient studies to prove the extent of involvement of a zinc deficiency in clinical cases of olfactory disorders. Future studies are awaited.

Conclusion

For an example of disorders of sensory organs caused by zinc deficiency, a taste disorder was described in detail with special reference to its relationship with a deficit of this trace element. As a cause of the taste disorder, zinc deficiency is clinically significant. Treatment with zinc preparations has been found to be highly effective in cases with idiopathic or zinc deficiency-induced taste disorders.
REFERENCES


