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Professional Oral Health Care by Dental Hygienists Reduced Respiratory Infections in Elderly Persons Requiring Nursing Care

Mieko ADACHI^{1*}, Kazuyuki Ishihara², Shu Abe² and Katsuji Okuda²

¹Division of Aging and Geriatric Dentistry, Tohoku University Graduate School of Dentistry, 4-1 Seiryouchou, Aobaku, Sendai, 980-8575, Japan

²Department of Microbiology, Tokyo Dental College, 1-2-2 Masago, Mihama-ku, Chiba 261-8502, Japan

Running title: Oral care reduces respiratory infection

*Corresponding author

Mieko ADACHI

Division of Aging and Geriatric Dentistry

Tohoku University Graduate School of Dentistry

4-1 Seiryouchou, Aobaku, Sendai, 980-8575

Japan

TEL: +81-43-270-3742

FAX: +81-43-270-3744

E-mail Address: mieko-a@k9.dion.ne.jp

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Abstract

Objectives: Respiratory infection is a major cause of death in the elderly. We have evaluated the role of professional oral health care (POHC) by dental hygienists in reducing respiratory infections in elderly persons requiring nursing care.

Methods: Two populations of elderly persons, one receiving POHC and one not, were examined to determine numbers of microorganisms, potent pathogens of respiratory infection, enzymatic activity in saliva, fevers, prevalence of fatal aspiration pneumonia and prevalence of influenza.

Results: In the first population, we found a high prevalence of potent respiratory pathogens such as *Staphylococcus* species, *Pseudomonas aeruginosa* and *Candida albicans*. Patients who received POHC showed a lower prevalence for these pathogens than those who did not. The ratio of fatal aspiration pneumonia in POHC patients was significantly lower than that in patients without POHC (non-POHC) over a 24-month period ($p < 0.05$). The prevalence of a fever of 37.8°C or more in POHC patients was significantly lower than that in the non-POHC group ($p < 0.05$). In the second study population, we investigated the effects of POHC on infection with influenza over a 6-month period. In the POHC group, neuraminidase and trypsin-like protease activities decreased, and one patient out of 98 was diagnosed with influenza; whereas, in the non-POHC group, 9 patients out of 92 were diagnosed with influenza. The relative risk of developing influenza while under POHC was 0.1 (95% CI 0.01-0.81, $p = 0.008$).

Conclusion: These results suggest that POHC by dental hygienists is effective in preventing respiratory infections in elderly persons requiring nursing care.

Key words: Aspiration pneumonia, Oral microflora, Oral Hygiene, Elderly, Compromised host, Nursing care, Influenza, Respiratory infection

Introduction

The microorganisms that colonize the human oral cavity have been associated with aspiration pneumonia (1-4). Cross-sectional and longitudinal studies have also shown that, despite their receiving close medical attention, the oral health status of elderly patients in nursing homes was poorer than that of people in the general population (1-4). Maintaining the physical health of those who require care because of illness, old age, or dementia is extremely difficult, and specialized oral health care by a qualified professional is indispensable. Conditions such as fever and bacterial respiratory infections may develop as a result of poor oral hygiene. Therefore, it is essential to provide the elderly with a suitable regimen of care that focuses on cleansing the oral cavity (5, 6). In earlier studies, we investigated the colonizing levels of anaerobic bacteria, *Staphylococcus* species, *Pseudomonas aeruginosa*, and *Candida albicans* in elderly persons needing professional nursing care and compared them with those in a healthy elderly group (7-10).

The mortality rate from aspiration pneumonia in older people under nursing care is very high (11, 12). Oral endogenous bacteria forming biofilms as supra-gingival and sub-gingival dental plaque may be the main pathogens involved in aspiration pneumonia. Although disinfectants and antibiotics are effective against floating bacteria in the oral cavity, these agents cannot penetrate as far as the central bacterial cells forming biofilms in the oral cavity. Therefore, mechanical cleaning such as that offered by professional oral health care (POHC) is considered the best method for eliminating biofilms, as it is more effective than using disinfectants or antibiotics. To determine what type of POHC is best suited for preventing aspiration pneumonia, it is necessary to accurately evaluate the level of oral hygiene in elderly people. Available indices for visually evaluating dental plaque accumulation include the Oral Hygiene Index and the Plaque Control Record. However, these indices are used to evaluate the risk of dental caries and periodontal disease, and are not suitable for the quantification of microorganisms in the saliva, which are the pathogens of silent aspiration pneumonia. An evaluation system is also required to determine the degree to which conventional methods work in preventing pneumonia. One of our objectives in this study was to determine the relationship between visual oral hygiene in elderly persons based upon dental plaque accumulation and numbers of bacterial cells in saliva, a risk factor for aspiration pneumonia.

Influenza is a major cause of respiratory infection and has a high mortality rate,

especially in elderly persons. In an earlier study, we demonstrated that POHC by dental hygienists had a significant effect in reducing influenza infections (13). We found that the relative risk of developing influenza while under professional oral care, compared to that of not being under professional oral care, was 0.1 (95% CI 0.01-0.81, $p = 0.008$). It is possible that a reduction in bacterial neuraminidase and trypsin-like protease in saliva by POHC was responsible for this increase in prevention of infection with the influenza virus.

I have reported the effectiveness of POHC by dental hygienists in reducing numbers of bacterial cells in saliva, prevalence of fever, rate of fatal aspiration pneumonia, amount of enzymatic activities in saliva, and rate of infection with influenza in elderly persons to clarify the importance of such care in maintaining health this population.

Study population and methodology

Subjects: To evaluate the effectiveness of oral care on respiratory infections in elderly persons, we performed 2 studies. In the first study, we investigated the relationship between oral care and aspiration pneumonia at two nursing homes for the elderly. In the second study, we investigated the relationship between oral care and occurrence of influenza infection in elderly persons who visited the same two nursing homes. The Tokyo Dental College Ethics Committee granted ethical approval for these studies, and written informed consent was obtained from the participants. A few, however, had dementia or some other condition that prevented them from giving fully informed consent. In such cases, consent was obtained from the director of the institute and the persons charged with the daily care of that patient. The patients had a variety of medical problems, and all were under medication of some kind.

Evaluation of oral condition: To evaluate oral hygiene, we utilized the Dental Plaque Index (DPI). There are three oral hygiene levels in the DPI: DPI 0, no visual dental plaque; DPI 1, plaque covers less than half of the tooth surface; and DPI 2, plaque covers more than half of the tooth surface. The Tongue Plaque Index (TPI), which evaluates tongue plaque status on the surface of the tongue, was also utilized. This consists of two levels: TPI 0, tongue plaque (-) and TPI 1, tongue plaque (+). Dentate participants were evaluated with both DPI and TPI, while edentate subjects were evaluated with TPI alone.

Oral care and aspiration pneumonia: In the first study, the experimental group consisted of patients receiving POHC by a dental hygienist, and the control group of patients who were not. POHC consisted mainly of mechanical cleaning. The teeth were brushed using an

electric brush with an automatic water supply (Dent-Eraku 910, Lion Co., Tokyo), an inter-dental brush, and a sponge brush; the teeth, the buccal mucosa, the tongue, and the dentures were all cleaned. In the control group, either the patient or a staff member of the nursing home and/or helper continued to administer basic oral hygiene as usual, which mainly consisted of swabbing with a sponge brush and denture cleaning. If some of the elderly patients required extra POHC during the course of the study, it was given, but the related data were excluded from the analysis. The nurses in the two nursing homes routinely took the temperatures of all nursing home patients at 07:00 and 15:00 hr every day. The various data were later collected and analyzed. Those patients with fevers of 37.8°C or above were considered to be feverish, as in previous similar studies.

Oral care and influenza infection: In the second study, we evaluated the effect of 6 months' POHC by dental hygienists in reducing the prevalence of influenza in elderly persons. The participants consisted of 216 elderly persons living in their own residences in Tokyo, and visiting day care service facilities once a week. All were randomly assigned to either a POHC group or a non-POHC group. Twenty-six persons dropped out of the study as a result of hospitalization or difficulties in visiting the day care center. From October, 2003 until April, 2004, one group received POHC once a week, while the other received conventional care. Cultivable bacterial cell numbers, and activities of neuraminidase and trypsin-like protease in saliva samples were evaluated in 98 persons in the POHC group. We looked for viable anaerobic bacterial cells in saliva using swab samples obtained from the dorsum of the tongue and oral mucosa, and detected species of *Staphylococcus*, including MRSA, *P. aeruginosa*, and *C. albicans*. Neuraminidase in saliva was measured with an Amplex Red Neuraminidase Assay Kit (Molecular Probes, Eugene, OR, USA), and trypsin-like protease was measured with a Perio Check (SUNSTAR Co, Takatsuki, Japan). We examined all the elderly persons who developed influenza during the intervention period. Influenza was diagnosed using the rapid antigen detection test QuickVue Kit (Quidel, San Diego, CA) for patients with influenza-like illnesses, which were specified as being characterized by coughing and a temperature of at least 37.8°C. Those who exhibited influenza-like symptoms, but who were diagnosed as not having influenza, were categorized as having developed a cold.

Results

Evaluation of oral condition: In the first study, we investigated the relationship between total febrile days in one year and oral hygiene using the DPI and TPI in dentate elderly persons and the TPI in edentulous persons. The poor oral hygiene groups had a higher DPI (Fig. 1A) and TPI (Fig. 1B) and showed a significantly higher mean number of febrile days than the good oral hygiene elderly groups ($p < 0.01$). We also investigated aspiration pneumonia episodes. In the dentate group, both the number of febrile days and the number of patients who developed pneumonia were significantly higher for those ranked as DPI-poor as compared to those ranked as DPI-good ($p < 0.01$, Table 1). No relationship was found between pneumonia and TPI in dentate patients. No patients with pneumonia were found in the TPI-good hygiene group, but two such patients were found in the TPI-poor hygiene group. These results demonstrate a significant positive correlation between oral hygiene and number of febrile days, as well as with pneumonia.

Oral care and aspiration pneumonia: We examined the prevalence of fevers of 37.8°C or more in patients receiving POHC given by dental hygienists once a week for 24 months. At first, no significant difference was seen between the two groups. After 6 months, however, an effect was observed (Fig. 2A). The occurrence of fevers of 37.8°C or above in the POHC group was significantly lower than that in the non-POHC group (Fig. 2B).

In this study, ten elderly persons in the POHC group and 15 who did not receive POHC died during the 24-month period of observation (Table 2). Two of the 10 in the POHC group and 8 out of the 15 without POHC died of aspiration pneumonia. Therefore, the percentages of subjects in the POHC and non-POHC groups who died of aspiration pneumonia were 5.0 and 16.7%, respectively. Comparisons between the two groups using Fisher's exact test showed that the prevalence of fatal aspiration pneumonia in the POHC group was significantly lower than that in the non-POHC group ($p < 0.05$).

We evaluated the effect of POHC by dental hygienists on reduction of potent pneumonia pathogens in the oral cavity. After performing POHC for 6 months, cultivable cell numbers were evaluated and compared with those in the non-POHC group. As shown in Fig. 3, the numbers of *C. albicans* in samples obtained after POHC were significantly lower than those in samples from the non-POHC group ($p < 0.001$ according to the Mann-Whitney U test). Although POHC also yielded a reduction in cultivable cell numbers of MRSA and *P. aeruginosa*, these figures were not statistically significant.

Oral care and influenza infection: In the second study population, we investigated the effects of POHC on infection with influenza in the winter season of 2003/2004. We confirmed that there were no significant differences in the baseline physical characteristics of the participants between the POHC group and non-POHC group. Total cultivable bacterial cells showed a significant reduction in those who received POHC, but not in the non-POHC group (Fig. 4A). We found a significant reducing effect on neuraminidase and trypsin-like protease in the saliva samples (Fig. 4 B and 4C)

Ten out of the 190 elderly persons in the second study who visited day care service facilities were diagnosed as influenza positive (Table 3). Nine (9.8%) individuals in the control group and one (1.0%) person in the POHC group were diagnosed with influenza. Among the elderly persons who were infected with influenza, 4 out of 9 elderly from the control group and one from the POHC group had been vaccinated. Although there was no significant difference in the rate of vaccination between the POHC and control group, the rate of influenza infection was significantly different. None of the dental hygienists who provided oral care developed influenza. The relative risk of developing influenza while under professional oral care compared to that of not being under professional oral care was 0.1 (95% CI 0.01-0.81, $p = 0.008$).

Discussion

In these studies, we set out to evaluate the effects of continuous POHC by dental hygienists in elderly persons on reducing the number of potential respiratory pathogenic microorganisms in the oral cavity, the prevalence of fevers, the incidence of fatal aspiration pneumonia and the prevalence of influenza. During sleep, the swallowing reflex weakens, especially in the elderly and in those with decreased activities of daily living (ADL). Furthermore, mucociliary clearance of the airways and the cough reflex are weaker in elderly persons with decreased ADL, so salivary bacteria released from biofilms on teeth, periodontal pockets, tongue and pharyngeal surfaces may be aspirated and reach the lungs where they can grow and cause pneumonia.

It has been shown that a combination of mechanical and chemical oral cleansing results in a significant reduction in the number of potential respiratory pathogens in the oral cavity. We found that POHC by dental hygienists resulted in a statistically significant reduction in the prevalence of fevers in elderly persons (7, 8, 10). We have suggested that POHC

reduces Gram-negative bacteria, which produce lipopolysaccharides, known to be a potent pyrogen, thus diminishing the incidence of fever (4). Another study has indicated selective modulation of microbial attachment to oral epithelial cells by enzymatic activities associated with poor oral hygiene (12). The cryptic receptors for various viruses in the upper respiratory mucous membranes are known to be covered by salivary components such as sialic acid, and these receptors may be exposed by microbial enzymatic activities (14, 15). It is possible that oral hygiene treatment reduces these enzymatic activities, resulting in inhibition of cold virus adsorption to air way membranes.

These present two studies have shown that POHC by dental hygienists reduces the incidence of influenza in elderly persons, and that such treatment given once a week for 6 months reduces both numbers of anaerobic bacteria and enzymatic activities in saliva. The influenza vaccination rate in the POHC group was 36.7%, and that in the control group was 42.4%, indicating that there was no significant difference between these two groups. However, the POHC group showed a significantly lower rate of infection with influenza compared to the controls. We found that the relative risk of developing influenza while under POHC was lower than in the controls. These results suggest the need for further longitudinal study covering a larger sample of subjects to verify the extent of the role of good oral hygiene in preventing respiratory infections in elderly people.

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Table 1. Pneumonia episodes and oral hygiene status according to DPI in dentate and TPI in edentulous patients

Pneumonia	DPI		TPI	
	Good (n=41)	Poor (n=20)	Good (n=31)	Poor (n=31)
Infected	0	2*	0	2
Non-infected	41	18	31	29

n: Number of patients, Mann-Whitney *U*-test *: $p < 0.05$

Table 2. Numbers and causes of death of 10 elderly persons in POHC group and of 15 elderly persons in non-POHC group over 24 months

	POHC group (40)	Non-POHC group (48)
Total deceased	10	15
Aspiration pneumonia	2*	8*
Ischemic diseases	8	6
Cancer	0	1

*: Statistically significant difference by Fisher's exact test ($p < 0.05$)

Table 3. Comparison of influenza vaccination and incidence of influenza between POHC and control groups*

	POHC group (n = 98)	Control group (n = 92)
Influenza vaccine (%)	39 (42.4)	36 (39.1)
Influenza (%)	1 (1.0)	9 (9.8) *

* Fisher's exact test; p=0.008

Fig. 1. Relationship between total febrile days in one year and oral hygiene DPI in dentate elderly and TPI in edentulous elderly. Values represent mean \pm standard error, **: $p < 0.01$

Fig. 2. Monthly percentage of patients with more than 37.8 °C in POHC and non-POHC groups (A) and comparison of average prevalence in patients with fever of more than 37.8 in POHC and non-POHC groups (B). *: $p < 0.05$ by Fisher's exact test.

Fig. 3. Comparison of cultivable cell numbers (average \pm standard deviation) of *Staphylococcus* species, methicillin-resistant *Staphylococcus aureus* (MRSA), *Pseudomonas aeruginosa*, and *Candida albicans* in swab samples obtained from 34 elderly persons with POHC for 6 months and non-POHC group. *: $p < 0.05$ by Mann-Whitney U test.

Fig. 4 POHC reduced cultivable bacterial cells (A), trypsin-like protease (B), and neuraminidase (C) in saliva samples. Values represent mean \pm standard error. Wilcoxon's rank sum test; *: $p < 0.05$

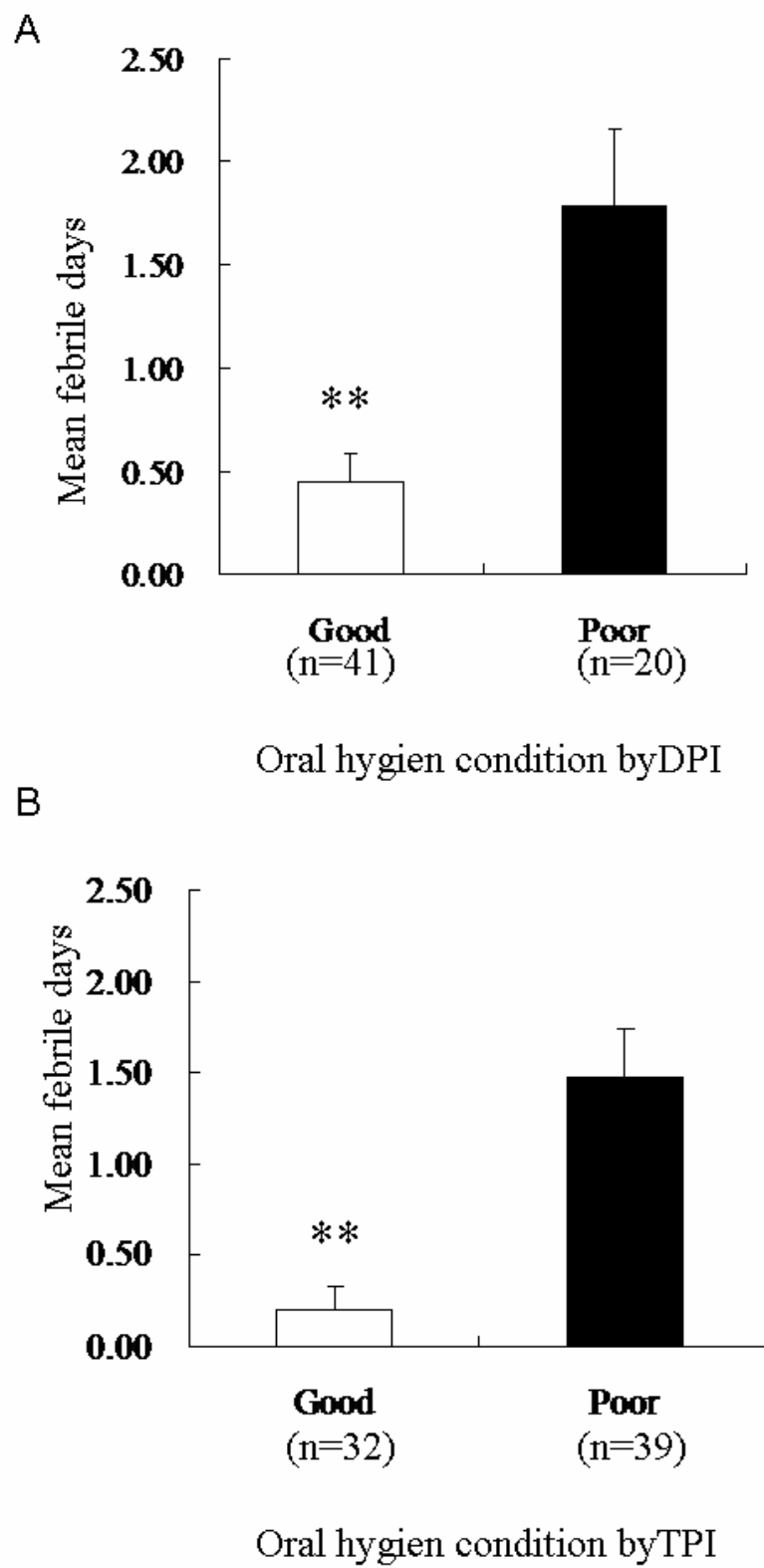
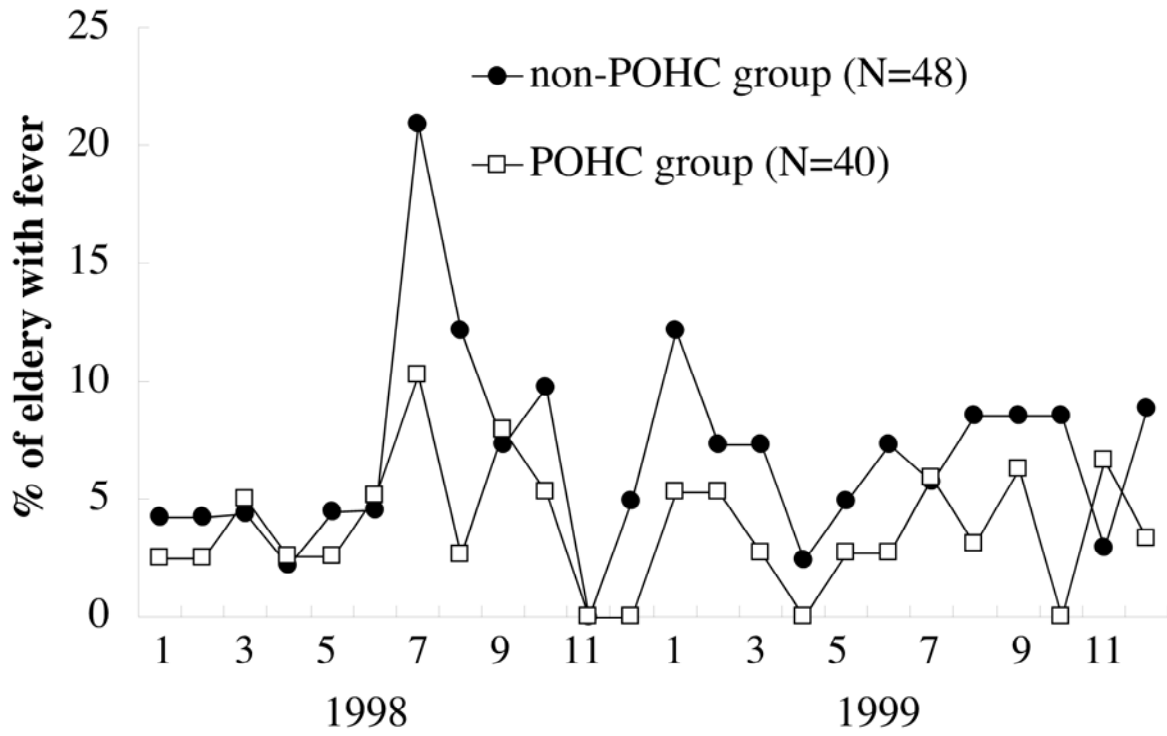


Fig. 1

A



B

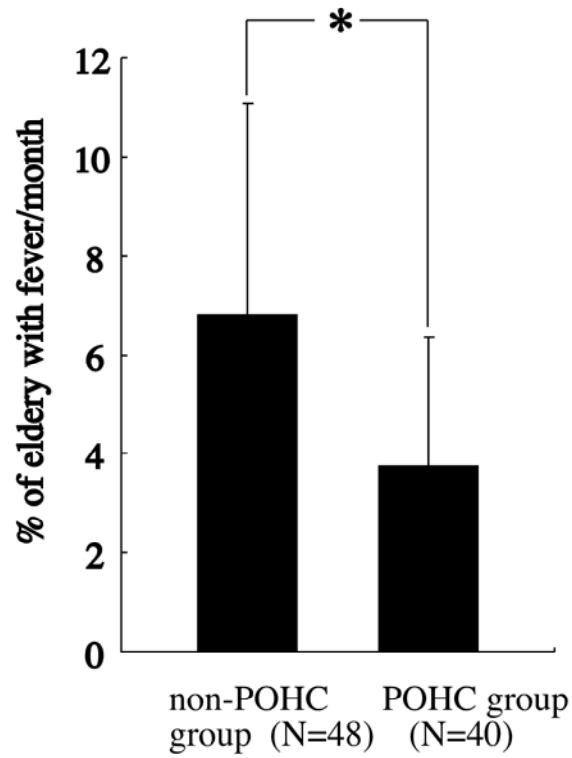


Fig. 2

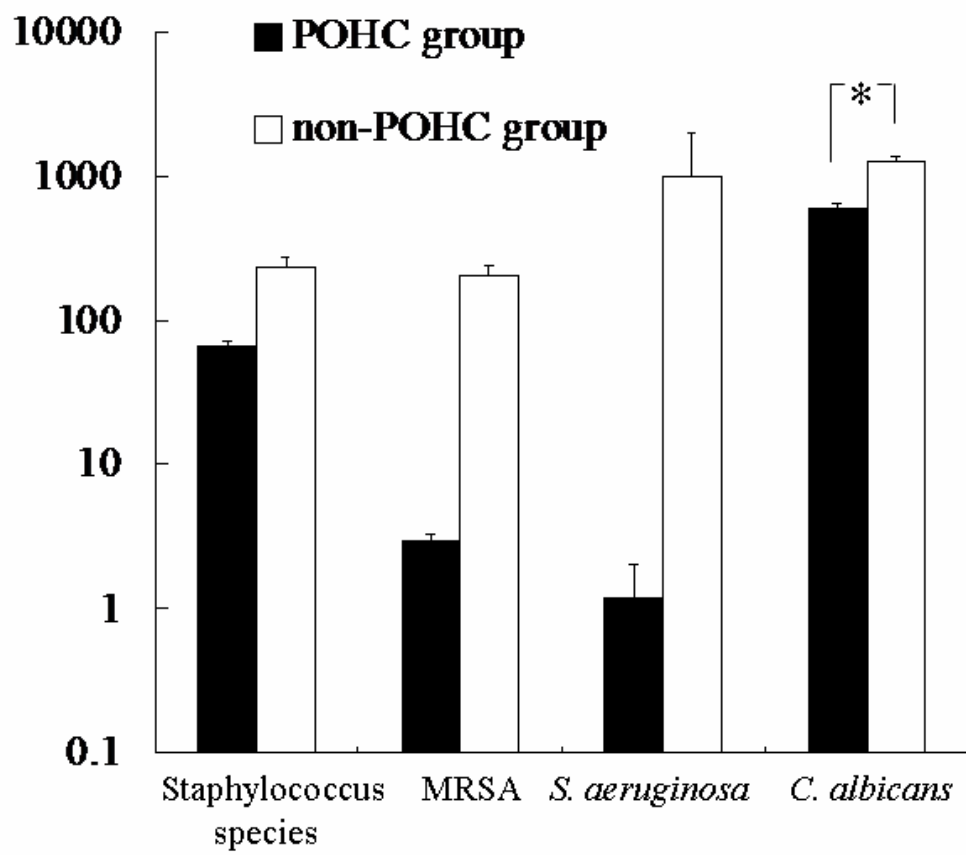


Fig. 3

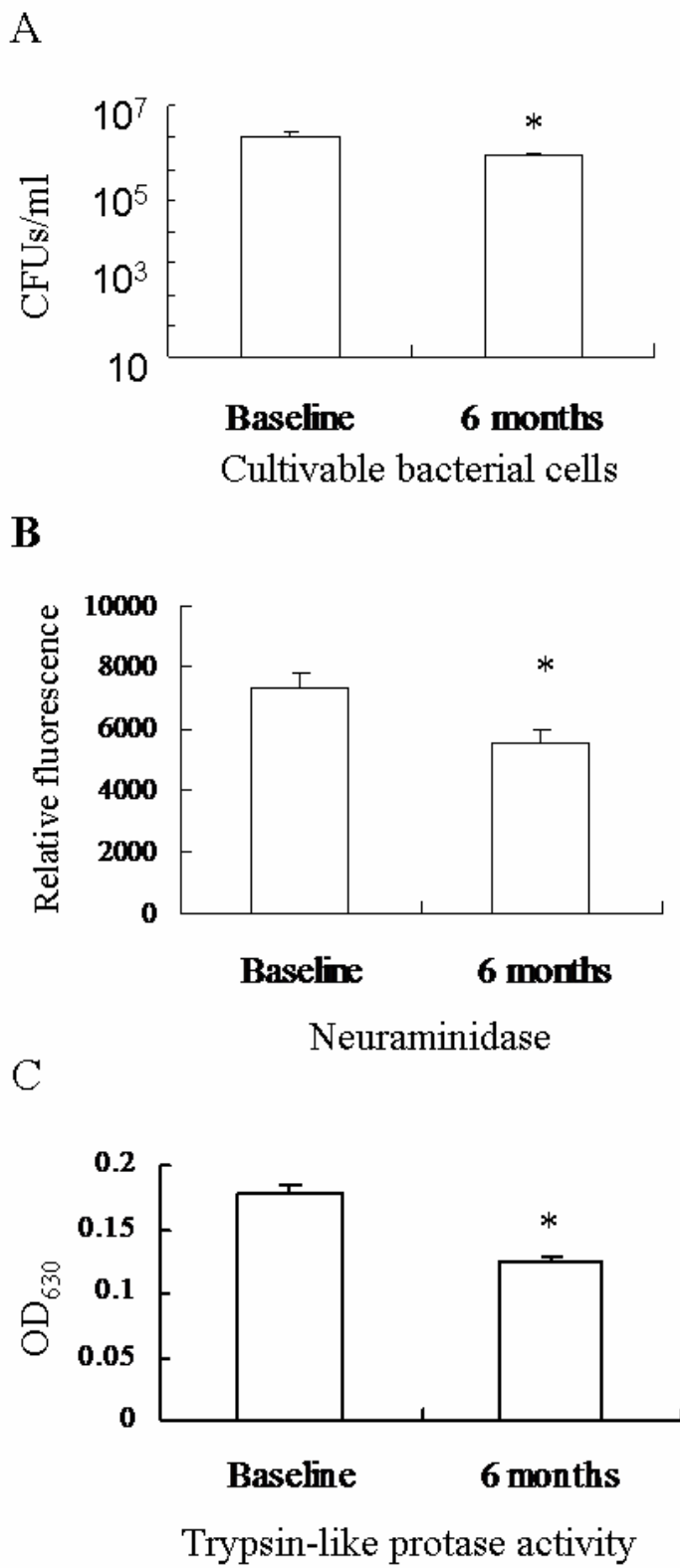


Fig4