In vitro adherence of Candida albicans isolated from patients with chronic periodontitis

Adriana Gadotti MACHADO1, Edson Yukio KOMIYAMA2, Silvana Soléo Ferreira dos SANTOS3, Antonio Olavo Cardoso JORGE4, Fernanda Lourenção BRIGHENTI5, Cristiane Yumi KOGA-ITO6

1- DDS, Graduate student, Department of Biosciences and Oral Diagnosis, São José dos Campos Dental School, State University of São Paulo - UNESP, São José dos Campos, Brazil.
2- DDS, MSc, Graduate student, Department of Biosciences and Oral Diagnosis, São José dos Campos Dental School, State University of São Paulo - UNESP, São José dos Campos, SP, Brazil.
3- DDS, MSc, PhD, Associate Professor, Department of Dentistry, University of Taubaté (UNITAU), Taubaté, SP, Brazil.
4- DDS, MSc, PhD, Full Professor, Department of Biosciences and Oral Diagnosis, São José dos Campos Dental School, State University of São Paulo - UNESP, São José dos Campos, SP, Brazil.
5- DDS, MSc, PhD, Postdoctoral Research Associate, Department of Biosciences and Oral Diagnosis, São José dos Campos Dental School, State University of São Paulo – UNESP, São José dos Campos, SP, Brazil.
6- DDS, MSc, PhD, Associate Professor, Department of Biosciences and Oral Diagnosis, São José dos Campos Dental School, State University of São Paulo - UNESP, São José dos Campos, SP, Brazil.

Corresponding address: Cristiane Yumi Koga-Ito - Faculdade de Odontologia de São José dos Campos - UNESP - Departamento de Bicências e Diagnóstico Bucal - Av. Eng. José Francisco Longo, 777 - 12245-000 - São José dos Campos, SP - Brasil - Phone: +55-12-3947-9033 - Fax: +55-12-3947-9010 - e-mail: cristiane@fobsjc.unesp.br

Received: July 24, 2009 - Modification: April 30, 2010 - Accepted: October 26, 2010

ABSTRACT

Adherence is considered an extremely important virulence factor in yeast. Objective: The aim of this study was to analyze the adherence to epithelial cells of C. albicans isolated from patients with chronic periodontitis in comparison to healthy patients. Material and methods: Candida albicans cells isolated from individuals with chronic periodontitis (n=25) and healthy controls (n=25) were included in this study. Suspensions of C. albicans (10^6 cells/mL) and epithelial cells (10^5 cells/mL) were mixed and incubated at 37°C for 1 h. The number of yeasts adhered to 25 epithelial cells was counted. Results: The number of C. albicans cells adhered to epithelial cells was statistically higher in the chronic periodontitis group than in the control group (Student’s t-test, p=0.000). Conclusion: The results of the present study suggest a higher Candida adherence of samples isolated from patients with chronic periodontitis.

Key words: Candida albicans. Cell adhesion. Periodontitis. Virulence factors.

INTRODUCTION

The presence of Candida spp. on oral cavity of healthy patients varies from 35 to 60%4. C. albicans is the most prevalent yeast of oral microbiota. It constitutes 60 to 70% of total isolates of this genus, followed by C. tropicalis and C. glabrata22.

It is not clear why some patients are infected with Candida sp. whereas others are not. Nutrition, bacterial interaction and the presence of specific antibodies in saliva have been suggested are relevant factors22.

Among predisposing factors for Candida sp. colonization there are endocrinal disorders, blood diseases, immunodeficiencies, antibiotic therapy, use of orthodontic appliances and total prosthesis29. The increase of Candida sp. infections is related to the wide use of large spectrum antibiotics, corticosteroids, anti-tumor agents, contraceptives and due to the increase of immunocompromised patients1.

Besides oral mucosa, recent studies have shown the presence of C. albicans in other oral sites such as root canal, including persistente infection22, caries lesions18 and periodontal pockets10,28. C. albicans express virulence factors that may have an important role to the pathogenesis of periodontal disease, such as the ability of penetrating the epithelium, inhibiting polymorphonuclear cells and causing lysis of monocytes1. Urzúa, et al.28
(2008) showed that C. albicans can colonize subgingival sites of patients with aggressive and chronic periodontitis. Javed, et al. 10 (2009) showed that clinical and salivary parameters of periodontal inflammation were higher in type 2 diabetic patients with oral C. albicans colonization. Gonzalez, et al. 7 (1987) evaluated the presence of yeasts of juvenile periodontitis punch biopsies and found an increase of yeasts frequency after antibiotics treatment and the presence of budding. The presence of Candida sp. and the development of opportunistic infections in subgingival sites are attributed to the use of broad spectrum antibiotics as an adjuvant 22.

Chronic periodontitis is one of the most common periodontal destructive diseases in adults. It is characterized by progressive loss of bone and soft tissue that support the teeth5,21. In cases that are refractory to conventional treatment, the presence of opportunistic microorganisms can be observed13,25. Candida spp. has been previously isolated from periodontal abscesses 4, advanced periodontitis25, AIDS patients16 and patients with chronic periodontitis treated with antibiotics8.

Specific factors affecting the distribution of oral Candida are saliva, pH, adhesion, cell surface hydrophobicity, hyphae formation and the expression of specific enzymes20. Moreover, Candida sp. is also relatively tolerant to innate and cell-mediated immunity4.

Adherence is considered an extremely important virulence factor in yeasts because colonization and infection of the oral tissues is directly related to their adherence capacity46. A higher phospholipase activity is related to a stronger adherence to epithelial cells and to a higher pathogenicity4. Previous data showed that there are no differences on antifungal susceptibility of Candida sp. isolates from chronic periodontitis in comparison to the control group13. On the other hand, studying superinfecting microorganisms, Oliveira, Jorge and Santos21 (2006) found that even 1,000 μg/mL minocycline was not sufficient to inhibit all periodontal tested isolates. Thus, it would be interesting to investigate deeply the virulence factors of periodontal isolates. The aim of this study was to analyze the adherence to epithelial cells of C. albicans isolated from patients with chronic periodontitis in comparison to healthy patients.

MATERIAL AND METHODS

This research project was approved by the Bioethics Committee of São José dos Campos Dental School/UNESP, Brazil (Protocol number 72/99-PH/CEP).

Oral isolates from chronic periodontitis were previously obtained from 88 individuals aged from 25 and 62 years (41.33±5.54), with at least two periodontal sites with 5 mm and diagnosed clinically as chronic periodontitis patient, as described by Koga-Ito, et al. 13 (2004). Control group isolates were obtained from 68 healthy individuals aged from 25 to 55 years (34.45±7.93). Subgingival dental biofilm samples were collected by inserting 3 sterile paper points into the periodontal pocket, for 30 s and processed according to Loberto, et al. 15 (2004).

Candida albicans isolated from chronic periodontitis (n=25) and control individuals (n=25) were included in this study. The in vitro adherence test of C. albicans to epithelial cells were performed according to Macura and Tondrya 16 (1989) and Wellmer and Bernhardt 30 (1997). The samples were plated on Sabouraud dextrose agar (Difco, Bencton Dickinson, Detroit, MI, USA) and incubated at 37°C for 24 h. Next, 3 colonies were transferred to 40 mL of Sabouraud broth (Difco).

After incubation at 37°C for additional 24 h, the yeasts were Gram stained in order to verify the purity of the suspension. Next, the cells were centrifuged (3,000 g; 15’) and washed 3 times in 15 mL of saline phosphate buffer (PBS; pH 7.4). A suspension containing 10⁶ cells/mL was obtained in a Neubauer chamber (Laboroptik, Friedrichsdorf, Hesse, Germany) using the Trypan blue exclusion method.

The epithelial cells were obtained from healthy individuals by scraping a sterile wood spatula against the buccal mucosa. The cells were centrifuged (3,000 g; 30 s) and washed three times in PBS. A suspension containing 105 cells/mL was obtained with the aid of a Neubauer chamber (Laboroptik). Next, the suspensions of C. albicans and epithelial cell were mixed and incubated at 37°C for 1 h. C. albicans cells that did not adhered to epithelial cells were eliminated using a 12 mm isopore membrane (Millipore, Millipore Indústria e Comércio Ltda., São Paulo, SP, Brazil). The filter was stained with 50 mm of methylene blue (Vetec Química Fina, Duque de Caxias, RJ, Brazil) and the number of yeasts adhered to 25 epithelial cells was counted.

The results were analyzed by Student’s t-test (Minitab® 15.1.1.0. 2007, Minitab Inc, State College, PA, USA) comparing the number of candidal cells adhered to the epithelial cells in periodontitis and control groups. The significance level was set at 5%.

RESULTS

The number of C. albicans cells adhered to epithelial cells was significantly higher (p=0.000) in the chronic periodontitis group (15.28±2.32) than in the control group (6.44±1.20) (Figure 1).
Increased periodontal colonization by yeasts has been found in patients with reduced immunity, such as women using oral contraceptives and in HIV-positive patients with periodontal lesions. Candida sp. has also been correlated to cases of severe and refractory periodontal infections, particularly in immunocompromised patients or individuals under antimicrobial therapy for long periods. Despite Candida sp. isolation from patients with periodontitis and hyphal invasion in periodontal tissues, the role of Candida sp. in periodontal disease is still controversial.

To the best of our knowledge, this study shows for the first time the adhesion degree to epithelial cells of C. albicans isolated from chronic periodontitis sites and gives more insight on the pathogenesis and implications of Candida sp. in periodontal disease. C. albicans was used in the present study because it comprises 83.3% of the yeasts isolated from subgingival plaque of refractory periodontitis patients.

The identification of virulence factors of microorganisms present in gingival sulcus should be evaluated when considering a microorganism as possibly involved in periodontal disease. Several virulence factors have been attributed to Candida spp., such as dimorphism, phenotypic switching, interference on host’s immune systems, production of hydrolases, ability to respond to environmental changes, and ability to adhere to and invade into the epithelium. These factors are of possible relevance to periodontal disease.

Adherence is considered the first stage of the infection process for Candida sp. It is an essential step for the expression of the pathogenic potential and contributes for the persistence of the microorganism in the host, as the ability to adhere avoids microorganisms of being eliminated by saliva. Adherence is a complex and multifactorial process that involves several types of adhesions on a morphogenically changing cell surface.

The very low prevalence of C. albicans in the gingival crevicular fluid found by Ergun, et al. (2010) showed the importance of adherence ability for colonization of periodontal sites. To persist in the oral environment, microorganisms should attach to teeth or mucosa. Lack of adherence will lead the microorganisms to be removed by the continuous flow rate of the gingival crevicular fluid. Moreover, some periodontal conditions, such as nutrient limitation, may trigger phenotypic changes, like pleomorphism and tigmotropism, which represent an adaptive advantage for yeast colonization. Candida sp. colonization in periodontal environment is important not only for periodontal health but also for pulpal health. Pulpal colonization by Candida sp. in intact pulpal chambers demonstrated by Miranda, et al. (2009) suggests that these yeasts are able to invade pulpal tissue from periodontal sulcus.

In vitro adherence of C. albicans to buccal cells, vaginal cells and fibrin-platelet matrices has been shown. As germinated yeasts have been shown to have a great ability to adhere in vitro, germ tube formation is also implied in adherence development.

The fact that several Candida species, especially C. albicans, have been isolated from many types of periodontal diseases indicates that they are able to colonize subgingival environment. Using scanning electron microscopy, Gonzalez, et al. (1987) showed yeasts invading the gingival connective tissue of patients with juvenile periodontitis. Järvensivu, et al. (2004) suggested that C. albicans may play a role in the structure and adherence of periodontal biofilm present on chronic periodontitis. These authors observed the presence of Candida hyphae at the border of the sulcular epithelium and in the underlying connective tissue. The predominance of hyphae in the samples supports the visual finding of candidal tissue penetration and attachment.

Brusca, et al. (2010) found a significant association between Candida and periodontitis only for C. parapsilosis, suggesting that C. albicans is not related to periodontitis. However, Lima-Neto, et al. (2009) showed a higher affinity of C. albicans for epithelial cells than C. parapsilosis, which is in accordance with Repentigny, et al. (2000). Although only C. albicans were evaluated in the present study, the findings of the present study show that C. albicans may also be related to chronic periodontal disease, as its adherence was significantly higher.

Järvensivu, et al. (2004) showed the presence of C. albicans and the extent of gingival penetration in patients with chronic periodontitis. These authors found that C. albicans may play a role in the infrastructure of periodontal microbiota as
well as on adherence of periodontal tissues, which corroborates with the results of the present study.

Although the role of *C. albicans* in periodontal diseases has not yet been established, this yeast is considered as important on disease persistence and progression. The results of the present study suggest a higher adherence of samples isolated from patients with chronic periodontitis, which may be correlated to a higher pathogenicity of these isolates. These findings are in agreement with those of Calderone and Braun5 (1991), who found a positive correlation between *C. albicans* adherence to host surfaces and pathogenicity. Further studies are needed to determine the pathogenicity of yeasts isolated from periodontal disease, to better understand the putative role of yeasts as periodontopathogens, and to identify anatomic differences between yeasts isolates.

REFERENCES

1- Barrett-Bee K, Hayes Y, Wilson RG, Ryley JF. A comparison of phospholipase activity, cellular adherence and pathogenicity of yeasts. J Gen Microbiol. 1985;131:1217-21.

2- Brusca MI, Rosa A, Albaina O, Moragues MD, Verdugo F, Pontón J. The impact of oral contraceptives on women's periodontal health and the subgingival occurrence of aggressive periodontopathogens and Candida species. J Periodontol. 2010;81:1010-8.

3- Budtz-Jørgensen E. Histopathology, immunology, and serology of oral yeast infections. Diagnosis of oral candidosis. Acta Odontol Scand. 1990;48:37-43.

4- Burford-Mason AP, Weber JC, Willoughby JM. Oral carriage of Candida albicans, ABO blood group and secretor status in healthy subjects. J Med Vet Mycol. 1988;26:49-56.

5- Calderone RA, Braun PC. Adherence and receptor relationships of Candida albicans. Microbiol Rev. 1991;55:1-20.

6- Ergun S, Ceçi A, Topcuoglu N, Migliari DA, Külekçi G, Tanyeri H, et al. Oral status and Candida colonization in patients with Sjögren’s Syndrome. Med Oral Patol Oral Cir Bucal. 2010;15:e310-5.

7- González S, Lobos I, Guajardo A, Celis A, Zemelman R, Smith CT, et al. Yeasts in juvenile periodontitis. Preliminary observations by scanning electron microscopy. J Periodontol. 1987;58:119-24.

8- Hevoluo H, Hakkarainen K, Paunio K. Changes in the prevalence of subgingival enteric rods, staphylococci and yeasts after treatment with penicillin and erythromycin. Oral Microbiol Immunol. 1993;8:75-9.

9- Järvenisvu A, Hietanen J, Rautemaa R, Sorsa T, Richardson M. Candida yeasts in chronic periodontitis tissues and subgingival microbial biofilms in vivo. Oral Dis. 2004;10:106-12.

10- Javed F, Klingspor L, Sundin U, Altamash M, Klinge B, Engström PE. Periodontal conditions, oral Candida albicans and salivary proteins in type 2 diabetic subjects with emphasis on gender. BMC Oral Health. 2009;9:12.

11- Kimura LH, Pearsall NH. Relationship between germination of Candida albicans and increased adherence to human buccal epithelial cells. Infect Immun. 1980;28:464-8.

12- King RD, Lee JC, Morris AL. Adherence of Candida albicans and other Candida species to mucosal epithelial cells. Infect Immun. 1980;27:667-74.

13- Koga-Ito CY, Paiva Martins CA, Loberto JC, Santos SS, Jorge AO. In vitro antifungal susceptibility of Candida spp. isolates from patients with chronic periodontitis and from control patients. Braz Oral Res. 2004;18:80-4.

14- Lima-Neto RG, Beltrão EI, Oliveira PC, Neves RP. Adherence of Candida albicans and Candida parapsilosis to epithelial cells correlates with fungal cell surface carbohydrates. Mycoses. 2011;54:23-9.

15- Loberto JCS, Martins CAP, Santos SSF, Cortelli JR, Jorge AOC. Staphylococcus spp. in the oral cavity and periodontal pockets of chronic periodontitis patients. Braz J Microbiol. 2004;35:64-8.

16- Macura AB, Tondyra E. Influence of some carbohydrates and concanavalin A on the adherence of Candida albicans in vitro to buccal epithelial cells. Zentralbl Bakteriol. 1989;272:196-201.

17- Maisch F, Calderone RA. Adherence of Candida albicans to a fibrin-platelet matrix formed in vitro. Infect Immun. 1980;27:650-6.

18- Marchant S, Bralisford SR, Twomey AC, Roberts GJ, Beighton D. The predominant microflora of nursing caries lesions. Caries Res. 2001;35:397-406.

19- Miranda TT, Vianna CR, Rodrigues L, Monteiro AS, Rosa CA, Corrêa A Jr. Diversity and frequency of yeasts from the dorsum of the tongue and necrotic root canals associated with primary apical periodontitis. Int Endod J. 2009;42:839-44.

20- Naglik JR, Challacombe SJ, Hube B. Candida albicans secreted aspartyl proteinases in virulence and pathogenesis. Microbiol Mol Biol Rev. 2003;67:400-28.

21- Oliveira LF, Jorge AO, Santos SS. In vitro minocycline activity on superinfecting microorganisms isolated from chronic periodontitis patients. Braz Oral Res. 2006;20:202-6.

22- Pinheiro ET, Gomes BP, Ferraz CC, Sousa EL, Teixeira FB, Souza-Filho FJ. Microorganisms from canals of root-filled teeth with periapical lesions. Int Endod J. 2003;36:1-11.

23- Rams TE, Babalola OO, Slots J. Subgingival occurrence of enteric rods, yeasts and staphylococci after systemic doxycycline therapy. Oral Microbiol Immunol. 1990;5:166-8.

24- Repentigny L, Aumont F, Bernard K, Belhumeur P. Characterization of binding of Candida albicans to small intestinal mucin and its role in adherence to mucosal epithelial cells. Infect Immun. 2000;68:3172-9.

25- Slots J, Rams TE, Listgarten MA. Yeasts, enteric rods and pseudomonas in the subgingival flora of severe adult periodontitis. Oral Microbiol Immunol. 1988;3:47-52.

26- Socransky SS, Haffajee AD. Microbial mechanisms in the pathogenesis of destructive periodontal diseases: a critical assessment. J Periodontol Res. 1991;26:195-212.

27- Stenderup A. Oral mycology. Acta Odontol Scand. 1990;48:3-10.

28- Urzúa B, Hermosilla G, Gamonal J, Morales-Bozo I, Canals M, Barahona S, et al. Yeast diversity in the oral microbiota of subjects with periodontitis. Candida albicans and Candida dubliniensis colonize the periodontal pockets. Med Mycol. 2008;46:783-93.

29- Webb BC, Thomas CJ, Willcox MD, Harty DW, Knox KW. Candida-associated denture stomatitis. Aetiology and management: a review. Part 1. Factors influencing distribution of Candida species in the oral cavity. Aust Dent J. 1998;43:45-50.

30- Wellmer A, Bernhardt H. Adherence on buccal epithelial cells and germ tube formation in the continuous flow culture of clinical Candida albicans isolates. Mycoses. 1997;40:363-8.