Review Article

Isolation and Identification of Candida from the Oral Cavity

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Various techniques are available for the isolation of Candida within the oral cavity. Such methods play an important role in the diagnosis and management of oral candidosis. The growing importance of Candida is in part related to the emergence of HIV infection and the more widespread use of immunosuppressive chemotherapy. Along with the Candida albicans there has been a greater recognition of the importance of the nonalbicans Candida species in oral candidosis. Identification of infecting strains of Candida is important because isolates of Candida species differ widely, both in their ability to cause infection and also in their susceptibility to antifungal agents. Thus this review provides an overview of the reliable methods of candidal isolation and identification of isolates from the oral cavity.

1. Introduction

The term Candida originates from the Latin word candid, meaning white. The spores of Candida are a commensal, harmless form of a dimorphic fungus that becomes invasive and pathogenic pseudohyphae when there is a disturbance in the balance of flora or in debilitation of the host [1].

The translation of this endogenous commensal to the disease-causing parasite may be associated with factors other than the pathogenic attributes of the organism itself, which is rather unique compared with most of the other infectious diseases, where the virulence of the organisms considered being the key factor in the pathogenesis. Hence Candida species are strictly opportunistic. It could be stated with that neither the superficial nor the systemic forms of Candida infections could be initiated in the absence of underlying pathology [2].

There are many species of Candida (Table 1), [3] but the most prevalent one which is recovered from the oral cavity, in both commensal state and in cases of oral candidosis, is C. albicans. It is estimated that this species accounts for over 80% of all oral yeast isolates.

In recent years there has been an increased interest in infections caused by the opportunistic pathogen Candida. The growing importance of Candida is in part related to the emergence of HIV infection and the more widespread use of immunosuppressive chemotherapy [4, 5]. Identification of infecting strains of Candida is important because isolates of Candida species differ widely, both in their ability to cause infection [6] and also in their susceptibility to antifungal agents [7].

Along with the C. albicans there has been a greater recognition of the importance of the non-albicans Candida species in human disease. C. glabrata and C. krusei are species that have received attention due to their enhanced resistance to certain antifungal agents. C. dubliniensis is a recently identified pathogenic species, first described in 1995 when it was coisolated with C. albicans from cases of oral candidosis in HIV infected individuals [8].

This review provides an overview of the reliable methods of candidal isolation and identification of isolates from the oral cavity.

2. Pathogenic Attributes of Candida

The transition of Candida from a harmless commensal to a pathogenic organism is complex and is related to subtle environmental changes that lead to expression of a range of virulence factors (Table 2). It is the combined effect of both
host and candidal factors that ultimately contribute to the
development of oral candidosis [8].

Regardless of the type of candidosis, the ability of
*Candida* species to persist on mucosal surfaces of healthy
individuals is an important factor contributing to its viru-
lence. This is particularly important in the oral cavity, where
the organism has to resist the mechanical washing action of
a relatively constant flow of saliva toward the esophagus [9].

No single predominant virulence factor for *Candida* is
recognized although there are a number of factors that have
been implicated in promoting the infection process. These
include attributes involved in the adhesion of *Candida* to
oral surfaces (e.g., relative cell surface hydrophobicity and
the presence of specific adhesin molecules), the ability to resist
host immune defence mechanisms (e.g., high frequency
phenotypic switching and morphological transition), and
the release of hydrolytic enzymes (e.g., secreted aspartyl
proteinas and phospholipases) that can induce damage to
host cells [8].

### 3. Oral Candidosis

Samaranayake [10] proposed a classification where the oral
candidosis lesions were subdivided into two main groups:
Group I, or primary oral candidoses confined to lesions
localized to the oral cavity with no involvement of skin or
other mucosae; Group II or secondary oral candidoses, where
the lesions are present in the oral as well as extraoral sites
such as skin (Table 3). Group I lesions consist of the classic
triad—pseudomembranous, erythematous, and hyperplastic
variants—and some have suggested further subdivision of
the latter into plaque-like and nodular types [11].

### 4. Diagnosis of Oral Candidosis

Diagnosis of oral candidosis can often be made on the nature
of the clinical presenting features although microbiological
specimens should be taken if possible in order to both
identify and quantify any *Candida* that may be present and
provide isolates for antifungal sensitivity testing.

### 5. Methods of Isolation

Techniques available for the isolation of *Candida* within the
oral cavity include the use of a smear, a plain swab [8],
an imprint culture [12], collection of whole saliva [13],
the concentrated oral rinse [14], and mucosal biopsy. Each
method has particular advantages and disadvantages and the
choice of sampling technique is primarily governed by the
nature of the lesion to be investigated (Table 4). Where an
accessible and defined lesion is evident, a direct sampling
approach such as the use of a swab or an imprint is often
preferred as this will provide information of the organisms
present at the lesion itself. In cases where there are no obvious
lesions or in instances where the lesion is difficult to access,
an indirect sample based on culturing saliva specimens or an
oral rinse is more acceptable.

Quantitative estimation of fungal load can be done using
imprints, concentrated oral rinse, and culturing of oral rinse,
as a means of differentiating between commensal carriage
and pathogenic existence of oral *Candida*, with higher loads
considered likely in the latter [8].

### 6. Direct Microscopy

Morphological features of *Candida* species [15] (Table 5)
need to be examined for identification. A smear is of value
in differentiating between yeast and hyphal forms but is less
sensitive than cultural methods [16]. Potassium hydroxide
(KOH) preparation of the specimen reveals nonpigmented
septate hyphae with characteristic dichotomous branching
(at an angle of approximately 45°) [17]. In KOH-Calcofluor
fluorescent-stain method fungal characteristics like hyphae,
yeast cells, and other fungal elements will fluoresce [18].

A smear taken from the lesional site is fixed on to
microscope slides and then stained either by the gram stain
or by the periodic acid Schiff (PAS) technique. Using these
methods, candidal hyphae and yeasts appear either dark blue
(Gram-stain) or red/purple (PAS) [19].

In case of chronic hyperplastic candidosis, a biopsy of
the lesion is necessary for subsequent detection of invading
*Candida* by histological staining using either the PAS or
Gomori’s methenamine silver stains. Demonstration of
fungal elements within tissues is done as they are dyed deeply
by these stains. The presence of blastospores and hyphae or
pseudohyphae may enable the histopathologist to identify
the fungus as a species of *Candida* and, given the presence of
other histopathological features, make a diagnosis of chronic
hyperplastic candidosis [20].

### 7. Laboratory Culture

#### 7.1. Swab

A swab of a lesional site is a relatively simple
method of detecting growth and semiquantitative estimation
of *Candida* can be obtained. The sampling approach involves
gently rubbing a sterile cotton swab over the lesional
and then subsequently inoculating a primary isolation
medium such as Sabouraud’s dextrose agar (SDA) [21].

#### 7.2. Concentrated Oral Rinse

The oral rinse technique involves the patient holding 10 mL of sterile phosphate-
buffered saline (0.01 M, pH 7.2) in the mouth for 1 minute. The solution is then concentrated (10-fold) by centrifugation

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**Table 1: Species of Candida.**

*Candida albicans*
*Candida glabrata*
*Candida dublensis*
*Candida guilliermondii*
*Candida krusei*
*Candida lusitaniae*
*Candida parapsilosis*
*Candida tropicalis*
*Candida kefyr*

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**Table 2: Classification of Candida.**

- **Group I**
  - Pseudomembranous
  - Erythematous
  - Hyperplastic

- **Group II**
  - Localized to oral cavity with no involvement of skin or other mucosae
  - Secondary oral candidoses

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**Table 3: Oral Candidosis Lesions.**

- **Group I**
  - Pseudomembranous
  - Erythematous
  - Hyperplastic

- **Group II**
  - Localized to oral cavity with no involvement of skin or other mucosae
  - Secondary oral candidoses

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**Table 4: Sampling Techniques.**

- **Swab**
- **Imprint Culture**
- **Collection of Whole Saliva**
- **Concentrated Oral Rinse**
- **Mucosal Biopsy**

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**Table 5: Morphological Characteristics of Candida.**

- **Nonpigmented Septate Hyphae**
- **Dichotomous Branching**
- **Dark Blue (Gram-stain)**
- **Red/Purple (PAS)**

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Table 2: Virulence factors associated with *Candida Albicans*.

| Virulence factor                                  | Effect                                      |
|---------------------------------------------------|---------------------------------------------|
| Adherence                                        | Promotes retention in the mouth             |
| Relative cell surface hydrophobicity              | Nonspecific adherence process               |
| Expression of cell surface adhesion molecules     | Facilitates specific adherence mechanisms   |
| Evasion of host defenses                         | Promotes retention in the mouth             |
| High frequency phenotypic switching               | Antigenic modification through frequent cell surface changes |
| Hyphal development                                | Reduces likelihood of phagocytosis; allows phagocytosed yeast to escape phagocyte |
| Secreted aspartyl proteinase production           | Secretary IgA destruction                   |
| Binding of complement molecules                   | Antigenic masking                           |
| Invasion and destruction of host tissue           | Enhances pathogenicity                      |
| Hyphal development                                | Promotes invasion of oral epithelium        |
| Secreted aspartyl proteinase production           | Host cell and extracellular matrix damage   |
| Phospholipase production                          | Damage to host cells                        |

Table 3: Classification of oral candidosis.

| Primary oral candidosis (Group I) | Secondary oral candidosis (Group II) | Condition                                      | Subgroup |
|-----------------------------------|--------------------------------------|------------------------------------------------|----------|
| The “primary triad”:              |                                      |                                                |          |
| Pseudomembranous (mainly acute)   | Familial chronic mucocutaneous candidosis | 1                                              |          |
| Erythematous (acute/chronic)      | Diffuse chronic mucocutaneous candidosis | 2                                              |          |
| Hyperplastic (mainly chronic)     | Candidosis endocrinopathy syndrome    | 3                                              |          |
| (i) Plaque-like                   | Familial mucocutaneous candidosis     | 4                                              |          |
| (ii) Nodular/speckled             | Severe combined immunodeficiency      | 5a                                             |          |
| *Candida*-associated lesions      | Di George syndrome                    | 5b                                             |          |
| Denture stomatitis                | Chronic granulomatous disease         | 5c                                             |          |
| Angular cheilitis                 | Acquired immunodeficiency syndrome    | 6                                              |          |
| Median rhomboid glossitis         |                                        | –                                              |          |
| Linear gingival erythema          |                                        | –                                              |          |

Table 4: Methods of recovering *Candida* from the oral cavity.

| Isolation method                  | Advantages                                             | Disadvantages                                 |
|-----------------------------------|--------------------------------------------------------|-----------------------------------------------|
| Culture of whole saliva           | Sensitive; viable organisms isolated                   | Problems may occur with collection of sample; not site specific |
| Concentrated oral rinse            | Quantitative; viable cells isolated                    | Some patients have difficulty in using rinse; not site specific |
| Swab                              | Simple to use; viable cells isolated; site specific    | Difficult to standardize                      |
| Smear                             | Simple to use; not reliant on culture                  | Viable cells not determined; species identity not readily confirmed |
| Imprint culture                   | Quantitative; viable cells isolated; site specific     | Some sites difficult to sample                |
| Biopsy                            | Essential for chronic hyperplastic candidosis          | Invasive; not appropriate for other forms of candidosis |

and a known volume, usually 50 µL, inoculated on an agar medium using a spiral plating system. After 24–48 hrs incubation at 37°C, growth is assessed by enumeration of colonies and expressed as candidal colony forming units per mL (cfu mL⁻¹) of rinse [16].

7.3. Imprint Culture. The imprint method utilises a sterile foam pad of known size (typically 2.5 cm²), previously dipped in an appropriate liquid medium, such as Sabouraud’s broth, immediately before use. The pad is then placed on the target site (mucosa or intraoral prosthesis) for 30 seconds and then transferred to an agar for culture [16].

8. Culture Media

The most frequently used primary isolation medium for *Candida* is SDA [22] which, although permitting growth of *Candida*, suppresses the growth of many species of oral
bacteria due to its low pH. Incorporation of antibiotics into SDA will further increase its selectivity [8]. Typically SDA is incubated aerobically at 37°C for 24–48 hrs. Candida develops as cream, smooth, pasty convex colonies on SDA and differentiation between species is rarely possible [17]. It is estimated that more than one Candida species occurs in approximately 10% of oral samples and in recent years the ability to detect nonalbicans species has become increasingly important [16].

In recent years, other differential media have been developed that allow identification of certain Candida species based on colony appearance and colour following primary culture. The advantage of such media is that the presence of multiple Candida species in a single infection can be determined which can be important in selecting subsequent treatment options [8]. Examples of these include Pagano-Levin agar or commercially available chromogenic agars, namely, CHROMagar Candida, Albicans ID, Fluoroplate, or Candidchorm albicans [16].

Pagano-Levin agar distinguishes between Candida species based on reduction of triphenyltetrazolium chloride. The medium produces pale-coloured colonies of C. albicans, whilst colonies of other Candida species exhibit varying degrees of pink coloration. Pagano-Levin agar has a similar sensitivity to SDA but is superior for the detection of more than one species in the sample [23]. CHROMagar Candida identifies C. albicans, C. tropicalis, and C. krusei based on colony colour and appearance [24], whilst Albicans ID and Fluoroplate have proven beneficial for the presumptive identification of C. albicans [25]. The specificity of identification is reported to be 95% for CHROMagar Candida [26] and 98.6% for Albicans ID and Fluoroplate agars [25]. The use of CHROMagar Candida as a primary isolation agar has been cited as an approach that permits discrimination of the newly described C. dubliniensis [27] from C. albicans. On CHROMagar Candida, C. dubliniensis reportedly develops as darker green colonies compared with those of C. albicans [28]. However, discrimination between these two species using CHROMagar appears to decline upon subculture and storage of isolates. Failure of C. dubliniensis to grow on agar media at the elevated incubation temperature of 45°C has recently been suggested as an alternative test to discriminate between these two species [29].

9. Identification of Candida Species

Identification of yeasts based on primary culture media can be confirmed through a variety of supplemental tests traditionally based on morphological (Table 5) and physiological characteristics of the isolates.

9.1. Morphological Criteria. The germ-tube test is the standard laboratory method for identifying C. albicans. The test involves the induction of hyphal outgrowths (germ tubes) when subcultured in horse serum at 37°C for 2–4 hours. Approximately 95% of C. albicans isolates produce germ tubes, a property also shared by C. stellatoidea and C. dubliniensis [16].

C. albicans and C. dubliniensis can also be identified from other species based on their ability to produce morphological features known as chlamydospores. Chlamydospores are refractile, spherical structures generated at the termini of hyphae following culture of isolates on a nutritionally poor medium such as cornmeal agar. Isolates are inoculated in a cross hatch pattern on the agar and overlaid with a sterile coverslip. Agars are incubated for 24–48 hours at 37°C and then examined microscopically for chlamydospore presence [8].

9.2. Physiological Criteria/Biochemical Identification. Biochemical identification of Candida species is largely based on carbohydrate utilization. Traditional testing would have involved culture of test isolates on a basal agar lacking a carbon source. Carbohydrate solutions would then be placed within wells of the seeded agar or upon filter paper discs located on the agar surface. Growth in the vicinity of the carbon source would indicate utilization. Commercial systems are based on the same principle but test carbohydrates are housed in plastic wells located on a test strip. Growth in each well is read by changes in turbidity or colour changes in certain kit systems. Numerical codes obtained from the test results are used to identify the test organism based on database comparison [30].

9.3. Serology. Serological tests are frequently used to ascertain the clinical significance of Candida species isolates. Rising titers of IgG antibodies to C. albicans may reflect invasive candidiasis in immunocompetent individuals. The detection of IgA and IgM antibodies is important to identify an acute infection. Immunosuppressed individuals often show variability in antibody production and in such a case the use of an antigen detection test is recommended. Tests like enzyme linked immunosorbent assay (ELISA) and radio immuno assay (RIA) for detection of candidal antigen, either cell-wall mannan or cytoplasmic constituents are now available in developed countries [31].

Serological diagnosis is often delayed and the tests still lack sensitivity and specificity. Furthermore, antibody production in immunocompromised patients is variable, making diagnosis complicated [32]. This is due to the fact that fungal antigens and metabolites are often cleared rapidly from the circulation and the presence of antibodies does not always imply a Candida infection, especially in

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Table 5: Morphological features of Candida species.

| Feature             | 3–6                      |
|---------------------|--------------------------|
| Size (µm)           | Spherical or oval        |
| Shape               | Single; chains           |
| Number of buds      | Narrow                   |
| Attachment of buds  | Thin                     |
| Thickness           | Characteristic           |
| Pseudohyphae &/or hyphae | Single              |

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patients with serious underlying disease or who are taking immunosuppressive drugs [33].

Serologic tests are normally not a diagnostic tool for oral candidosis. However, such tests may be a prognostic instrument in patients with severe oral candidosis who respond poorly to antimycotic therapy [34].

9.4. Molecular-Based Identification Methods. Identification by analysis of genetic variability is a more stable approach than using methods based on phenotypic criteria. For the identification of Candida based on genetic variation are analyses of electrophoretic karyotype differences and restriction fragment length polymorphisms (RFLPs) using gel electrophoresis or DNA-DNA hybridization [16].

Species-specific PCR approaches have also been used for Candida species identification. Several target genes have been reported for Candida species discrimination, although those most frequently amplified are the sequences of the ribosomal RNA operon. Identification can be obtained based on PCR product sizes obtained following gel electrophoresis resolution, or PCR product sequence variation determined either by direct sequencing or through the use of restriction fragment analysis following cutting of PCR sequences with restriction endonucleases [8].

Fluorescence in situ hybridization with peptide nucleic acid method (PNA Fish) is a new detection technique which targets highly conserved species-specific sequences in the abundant rRNA of living C. albicans. Individual cells can be detected directly without the need for amplification [35]. This technique achieves a sensitivity of 98.7–100%, with a specificity of 100%, allowing for the discrimination of C. albicans from the phenotypically similar C. dubliiensiis [36].

Molecular-based technology can also be used to identify strains of Candida species although the use of techniques such as Pulsed Field Gel Electrophoresis (PFGE), Random Amplified Polymorphic DNA (RAPD) analysis, and repeat sequence amplification PCR (REP) are largely reserved for epidemiological investigations in research of oral candidosis [8].

10. Conclusion

In recent years a greater emphasis has been given for reliable identification of Candida species from human clinical samples. A schematic representation for candidal isolation and identification is presented in Figure 1. Since Candida is the resident microflora, appropriate isolation methods are required to ascertain the presence in the mouth along with their number. It is also important to identify the infecting
strains of *Candida* because isolates of *Candida* species differ widely, both in their ability to cause infection and also in their susceptibility to antifungal agents. Various phenotypic techniques are available for identifying isolated *Candida* including using morphological culture tests, differential agar media, and biochemical assimilation tests. These methods are supplemented with recent molecular techniques largely reserved for epidemiological investigations.

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