



Journal of
Dentistry and Oral Hygiene

Volume 6 Number 3, May 2014

ISSN 2006-9871



*Academic
Journals*

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Journal of Dentistry and Oral Hygiene

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Case Report

A case study of denture base resins on the adhesion of *Candida albicans* to prevent denture stomatitis

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Received 30 March, 2014; Accepted 12 May, 2014

The objective of this case report was to investigate whether *Candida albicans* adhesion to the poly(methyl methacrylate) (PMMA) denture surface is reduced by surface modifications in two innovative methods. Three experimental groups on the tissue surface of a maxillary denture consisted of a control (pure PMMA), negatively surface-charged modified-PMMA (*m*PMMA), and application of a self-bonding polymer (SBP). The results of the clinical report revealed that both *m*PMMA and SBP groups had reduced amounts of adherent *C. albicans* on the resin surfaces compared to the control. Interestingly, the SBP demonstrated a reduced amount of *C. albicans* adherence up to 21 days follow-up, where the *m*PMMA group exhibited a longer effect till 30 days.

Key words: Surface-charged resin, self-bonding polymer, *Candida albicans*.

INTRODUCTION

Denture stomatitis (DS) is a pathogenic condition of the denture-bearing palatal mucosa and is the most common form of candidal infection in the oral cavity (Regezi and Sciubba, 1989). In denture wearers, *Candida albicans*, a prevalent fungus in the mouth, has been the predominant species identified in cases with clinical signs of DS, which occurrence is often increased almost 3-fold, in geriatric populations (Reichart, 2000; Shulman et al., 2004; MacEntee et al., 1998; Cumming et al., 1990; Frenkel et al., 2000). Candidiasis, a fungal infection, is aggravated by the adhesion of *C. albicans* to the tissue-fitting surface

of a maxillary denture, which serves as an effective reservoir of microorganisms (Budtz-Jorgensen, 1981; Samaranayake et al., 1980; Vasilas et al., 1992; Thein et al., 2006).

In clinical situations, attempts have been made to inhibit candidal adhesion and subsequent colonization on the denture resin surface through the use of a wide range of antifungal agents. Mechanical plaque control by daily cleansing of denture surfaces and appropriate denture-wearing habits are considered important steps in preventing and treating the disease clinically. The exact

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Table 1. Polymerization of experimental surface-charged resin.

Chemical	Action	Ratio
PMMA : MMA	Polymer: Monomer	3:1 by weight
mPMMA (16% methacrylic acid)	Polymer: Monomer	3:1.5 by weight
Benzoyl peroxide	Initiator	1% weight of PMMA
2-Hydroxyethyl methacrylate	Cross-linker	0.5% volume of MMA
N,N dimethylaniline	Activator	0.5% volume of MMA

mechanism of adhesion of *Candida* species to the denture is yet to be elucidated, however, studies have shown that surface characteristics resulting from chemistry are significant in the initial adherence of *C. albicans* to the denture resin and offer an opportunity for further bonding and colonization (Lazarin et al., 2014; Wady et al., 2012; Park, 2007). Polymeric biomaterials feature an inherent advantage of their capacity for modification and dentures are made of poly(methyl methacrylate) (PMMA).

In this report, a patient's maxillary complete denture surface characteristics were modified with two different methods by: (1) incorporation of surface charge, and (2) application of a self-bonding polymer (SBP). The patient was followed up to 30 days after delivery of the surface modified maxillary complete denture.

CLINICAL REPORT

A 76-year-old male patient presented to the clinic with chief complaint of needing a new maxillary complete denture. The patient was completely edentulous in the maxilla and partially edentulous in the mandible. A review of the patient's health questionnaire and medical progress notes, as well as verbal communication, revealed that the patient had an ASA physical status II health history with a pre-diabetic condition. The patient had no known drug allergies or hypersensitivities. The patient's current medical and dental health was non-contributory to his dental treatment.

Upon fabrication of a new permanent maxillary complete denture, the new maxillary complete denture was duplicated to fabricate an experimental denture. The tissue-fitting surface of a maxillary complete denture was divided into three sections according to the type of surface treatment. Figure 1 describes the three different experimental area sections [Group 1: Control (pure PMMA), Group 2: Surface-charged modified-PMMA (mPMMA), and Group 3: SBP].

Group 1: Control

No surface modification or surface coating application, made of pure PMMA (0% methacrylic acid: 100% MMA).

Group 2: Surface-charged resins (mPMMA)

Surface-modification was achieved by incorporating methacrylic acid in a ratio of 16% methacrylic acid: 84% methyl methacrylate (Sigma-Aldrich Chemical Co., Inc., Milwaukee, Wisconsin), as shown in Table 1. Polymerization of the specimens was carried out

in water at $55 \pm 1^\circ\text{C}$ under air pressure of 20 psi for 15 min. The specimens were rinsed and stored in sterile distilled water for 24 h before use to remove any residual monomer after polymerization.

Group 3: Self-bonding polymers (SBP)

KISSCARE® Concentrated Gel (KISS-COTE Inc., Florida, USA) was applied according to manufacturer's instructions. For each resin sample, 10 mg of the KISSCARE® Dental Concentrated Gel was applied to spread completely over the experimental surface. Patient was given the duplicated maxillary complete denture and follow-up visits were done at 0, 3, 7, 10, 14, 17, 21, 24, and 30 days. The patient was instructed to follow up with regular denture hygiene procedures and was advised to remove the denture at night. On each follow-up visit, *C. albicans* swabs were done; each swab was transferred to a differential culture medium, CHROMagar® *Candida* (BD), and incubated at 37°C for 48 h. Growth was revealed as light to medium green colonies in Figure 2. The study protocol was reviewed by the Harvard Medical School/Harvard School of Dental Medicine Human Studies Committee.

The results of the present study revealed that both mPMMA and SBP groups had reduced amount of adherent *C. albicans* on the resin surfaces as compared to the control. Interestingly, SBP group demonstrated significantly reduced amount of *C. albicans* adherence up to 21 days follow-up, where the mPMMA group exhibited a longer effect till 30 days.

DISCUSSION

The etiology for edentulism is multifactorial; however, a study by Douglass et al. (2002) showed that the need of complete dentures would increase due to edentulism from 33.6 million adults in 1991 to 37.0 million adults in 2020, with a 79% increase in adult population over 55 years of age. In denture wearers, *C. albicans* have been the predominant species identified in most or all cases with clinical signs of denture stomatitis (McMullan-Vogel et al., 1999; Schou et al., 1987; Budtz-Jorgensen et al., 1975; Cardash et al., 1989; Marcos-Arias et al., 2009).

The present clinical report first identified that a novel negatively charged denture resin material could potentially reduce the adhesion of *Candida* on denture resin surfaces *in vivo*. Moreover, SBP showed to be an effective method of surface-coating in reducing staining of resin materials *in vivo* as previously demonstrated in

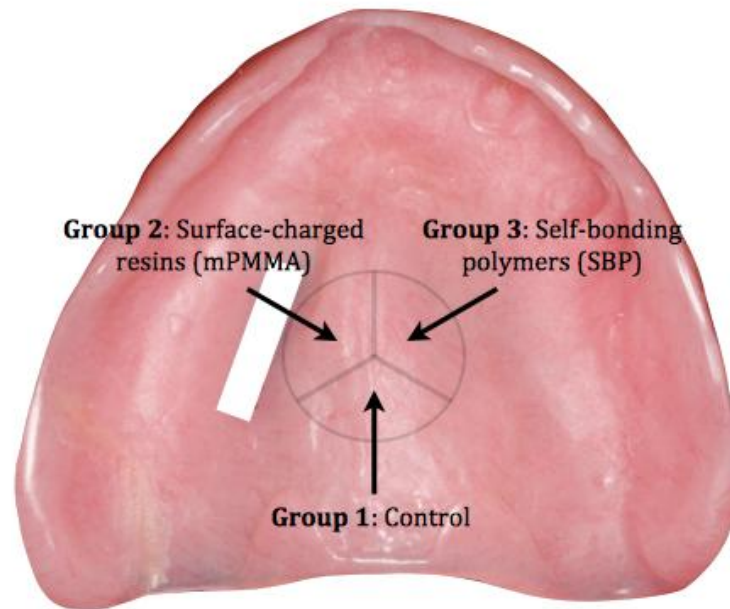


Figure 1. Tissue-fitting surface of maxillary complete denture.

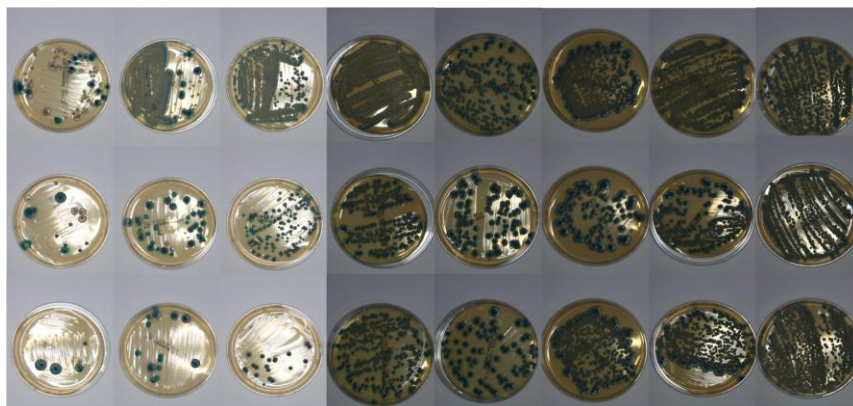
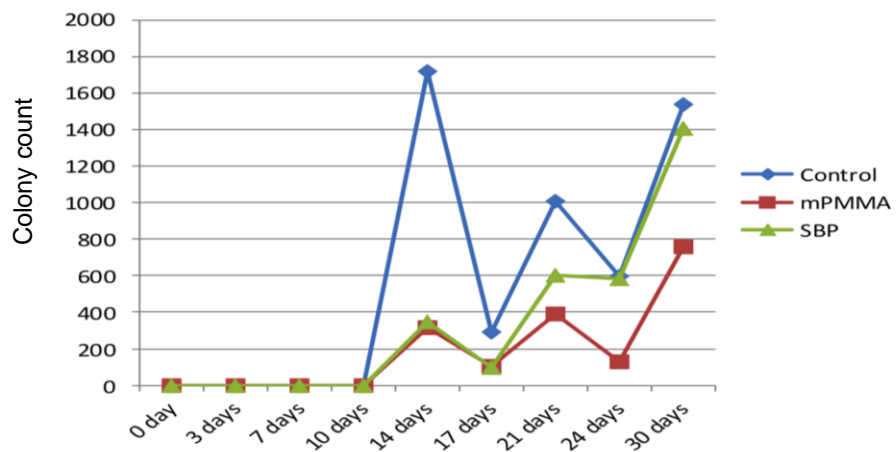


Figure 2. *Candida albicans* colony counts up to 30 days.

an *in vitro* study model (Park et al., 2006). The results of this case report were inherently influenced by the fluctuation of *C. albicans* counts attributed to the dynamic oral environment and patient's oral hygiene compliance. Other limitations of this study include the operator's techniques in sample collection and transfer to the medium.

Understanding the effect of electrostatic interactions in the adhesion of *Candida* to PMMA reduces the adhesion of *C. albicans* to the denture surface. PMMA is a negatively surface-charged denture resin modified by interacting polymerization of methacrylic acid to PMMA. This study had demonstrated the ability of this new surface-modified denture resin to reduce adhesion of *C. albicans* to the denture surface, showing significant correlation between the amount of methacrylic acid incorporated in resin and adhesion of *C. albicans* to the resin samples. This study supports the role of electrostatic interaction in adhesion, and introduced an effective method of reducing adhesion of *C. albicans* to PMMA surfaces through modification of the surface charge of polymeric biomaterials.

Another method to prevent the microbial adhesion to dental restorative materials is the application of a non-stick protective coating made of a pure poly(dimethyl siloxane). This SBP provides a mono-molecular layer of an inert non-stick finish to deter microbial attachment and growth (Park et al., 2003, 2008, 2009). Although, the SBP group demonstrated a short-term (21 days) efficacy, the feasibility of the duration of the SBP coating needs to be explored to determine whether multiple applications are required to maintain the continuing effect.

Modification of surface characteristics of polymeric biomaterials is an effective method in reducing adhesion of *C. albicans* to PMMA surfaces. Future studies should encompass the physiochemical properties of the acquired salivary pellicle layer formed on denture base surfaces and their roles in regulating microbial colonization to surface-charged biomaterials. Saliva composition, including calcium ion concentration and its pH value, is of importance in understanding microbial adhesion. Varying ratios of methacrylic acid need to be investigated to the surface charged polymers to find the optimal ratio for a dynamic oral environment.

Conflict of Interests

The author(s) have not declared any conflict of interests.

ACKNOWLEDGEMENTS

This research was supported in part by the American College of Prosthodontists/Proctor and Gamble Fellowship in Complete Denture Prosthodontics.

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Case Reports

Non surgical management of cutaneous sinus tract of odontogenic origin: A case report

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Received 14 March, 2014; Accepted 5 May, 2014

Cutaneous sinus tracts of dental origin are often initially misdiagnosed and inappropriately treated because of their uncommon occurrence and the absence of symptoms in approximately half the individuals affected. This paper reports a case describing the diagnosis and treatment of an extra-oral cutaneous sinus tract of odontogenic origin in relation to a mandibular left first molar. Non-surgical endodontic treatment was performed, and it resulted in resolution of the sinus tract and promoted peri-apical healing of the tooth involved.

Key words: Apical periodontitis, cutaneous sinus tract, necrosis pulp, non-surgical endodontic treatment.

INTRODUCTION

The sinus tract is defined as a channel leading from an enclosed area of inflammation to an epithelial surface. The opening of the sinus tract can be located either intraorally or extraorally (Cohenca et al., 2003). Cutaneous odontogenic sinus tracts of dental origin are uncommon. Although they have been well documented in the medical and dental literature, these lesions continue to be often misdiagnosed, challenging and pose a diagnostic dilemma (Cohenca et al., 2003; Susic et al., 2004). Studies revealed that the extra-oral sinus tracts are most commonly found on the cheek, chin and angle of the mandible (Slutzky-Goldberg et al., 2009; Magliocca et al., 2010; Vyas and Chaturvedi, 2011). Patients with cutaneous sinus tracts often undergo dermatological and other surgical interventions before being referred to the dentist. Therefore, all chronic draining sinus tracts of the face and neck signal the need of a thorough dental evaluation to avoid submitting patients to multiple biopsies,

antibiotic regimens and unnecessary surgery (Brown et al., 2010; Kansal et al., 2013).

Most commonly, the etiology of odontogenic sinus tracts involves a chronic periradicular abscess (Cantatore et al., 2002; Patni et al., 2010; Qazi et al., 2006). These abscesses arise from bacterial invasion, chemical irritation or trauma. The most common initiating factor of the periradicular abscess is carious exposure and subsequent bacterial invasion of the tooth pulp. The discharge of purulent exudates usually is associated with periapical radiolucent area and goes through tissues and structures along the path of least resistance (Kansal et al., 2013; Kell and Nahmias, 2007). The site of drainage can be located intra or extraorally, depending on certain circumstances such as the tooth which is diseased, and the apex position relatively to muscular attachments, bacterial virulence and lower host resistance (Pour et al., 2014; Sammut et al., 2013). The tracts occur more

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Figure 1. Pre-operative extraoral view of the sinus tract in the submandibular region.

frequently from peri-apical lesions caused by mandibular teeth (80%) than from those caused by maxillary teeth (20%), and this results in predominantly the appearance of cutaneous sinus tract of dental origin in the submental and submandibular regions. The tract rarely appears in the nasal region (Cantatore et al., 2002; Yuksel et al., 2010).

CASE REPORT

A healthy 18 year-old male was referred from the Department of Dermatology to the Department of Conservative Dentistry and Endodontic, EPS Farhat Hached (Sousse, Tunisia) to examine for possible dental infection. The patient was immediately put under double antibiotic therapy for 7 days (Amoxicillin 500 mg twice daily, Metronidazole 500 mg twice daily). The patient's chief complaint was the appearance of an extra-oral nodulous growth on his left cheek close to the lower border of the mandible for the past 6 months. On extra-oral examination, there was a 1 × 1 cm raised erythematous mass on the inferior aspect of the cheek with a central fistula (Figure 1). The lesion was not fixed to the underlying mandibular basilar region. The intra-oral examination revealed that the lower left first molar had a carious lesion with exposed pulp associated to a vestibular swelling. The tooth was not tender on percussion; respond negatively to the pulp sensibility test with pain on palpation. No sign of mobility or periodontal pocket were present in relation to tooth 36. A peri-apical radiograph revealed a large and well-circumscribed periradicular radiolucency associated with tooth 36 (Figure 2). Thus, the diagnosis of pulp necrosis with chronic peri-apical periodontitis with cutaneous sinus tract was made.

Tooth 36 was isolated with rubber dam, and a standard access cavity was prepared. The root canals were cleaned and shaped using rotary nickel-titanium Protaper® instruments (DentsplyMaillefer) and copiously irrigated with 2.5% sodium



Figure 2. Pre-operative radiograph showing periradicular radiolucency associated with tooth 36.



Figure 3. Working lengths radiograph.

hypochlorite and 17% EDTA. The working lengths were determined using electronic apex locator (Roor, META BIOMED) and established working lengths were controlled radiographically (Figure 3). Calcium hydroxide paste (MM-Paste™, Micro-Mega, Besançon, France) was placed as an intracanal medication and the access cavity was sealed with a temporary filling (MD-Temp™, META Biomed co, Korea) for two weeks. The patient was consulted after 5 days for follow-up. He was already showing good progress and less inflammation and swelling were observed (Figure 4). He reported a purulent discharge from the sinus tract. One week later, sinus tract was healed completely (Figure 5). The tooth was asymptomatic. After applying a rubber dam and removal of the intracanal dressing, the root canal was irrigated again and dried using paper point. The gutta-percha master cones were fitted and checked radiographically (Figure 6). The root canal obturation was performed with Protaper gutta-percha F3, Fine accessory cones



Figure 4. Good progress of the sinus tract's healing (5 days).



Figure 5. Complete heal of the sinus tract (2 weeks).

and sealer (MM-Seal™, Micro-Mega, Besançon, France) using the cold lateral condensation technique. A control radiograph was taken to assess the obturation (Figure 7). A temporary restoration (MD-Temp) was placed. The patient was recalled after 1 week for a permanent coronal restoration. He refused the use of amalgam and preferred an esthetic restoration. Therefore, a composite resin was used (Opallis, FGM, Brasil) (Figure 8). At the 6 month follow-up, the patient was comfortable without symptoms (Figure 9a). A follow up radiograph was taken and showing a considerable periapical healing with a decrease of the radiolucency (Figure 9b). Six months later, the patient returns for additional radiographic follow-up.

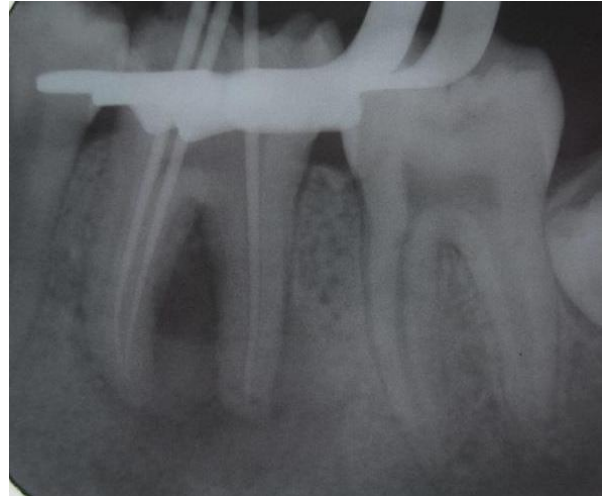


Figure 6. Radiograph with inserted gutta-percha cones.



Figure 7. Post-obturation radiograph.

Complete restitution of the periodontal tissue was observed with a perfect osseous repair (Figure 10).

DISCUSSION

The cutaneous sinus tract of dental origin is an uncommon but well documented condition. However, these lesions continue to be a diagnostic dilemma. Patients usually initially consult a general practitioner or a dermatologist due to the lack of dental symptoms and the unknown possible correlation (Yuksel et al., 2010). Roughly 50% of the patients affected have to deal with unnecessary surgical excisions, radiotherapy, antibiotic therapy and multiple biopsies before the correct diagnosis established (Varol and Gülses, 2009).



Figure 8. Composite resin restoration.

The odontogenic cutaneous sinus tract on the facial and cervical skin often develops as a result of chronic apical periodontitis caused by infected pulp necrosis (Mardones et al., 2010).

The apical infection may be spread through the marrow space, and then perforate the cortical bone. In soft tissue, the infection may be spread through the path of least resistance between facial spaces and finally perforate a mucosal or cutaneous surface (Satish et al., 2013; Nahmias et al., 2009). However, Chan et al. (1997) reported an extra-oral cutaneous sinus tract caused by vertical root fracture. Caliskan et al. (1995) also reported a case of cutaneous sinus tract originating from a fractured crown caused by trauma. The characteristic lesion is erythematous, smooth, symmetrical nodule, 1 to 20 mm in diameter. There is periodic drainage and crusting in some cases and the lesion is depressed below the normal skin surface. Palpation of the involved area often reveals a cord like tract attached to the underlying bone (maxilla or mandible) in the area of suspected tooth (Kayahan et al., 2003; Patni et al., 2010). Histologically, most of the sinus tracts were not epithelialized and only bordered by granulation tissue. It is commonly assumed that an epithelial lining may cause complications in healing. The longer the sinus tract exists, the more likely it is to have an epithelial lining (Sadeghi and Dibaei, 2011; Yuksel et al., 2010). Correct diagnosis of a cutaneous sinus tract of dental origin can be detected by correct oral investigation, visual inspection, tapping, pulp sensibility test and an intra-oral radiograph carried out with a gutta-percha cone placed in the sinus tract (Yuksel et al., 2010). In the case of this study, the causal tooth was evident, for that the radiograph was taken without gutta-percha in place. The differential diagnosis should include traumatic lesions, fungal and bacteriologic infections, neoplasms, presence of foreign body, local skin infection, pyogenic granuloma, chronic tuberculosis lesion, osteomyelitis, actinomycosis and gumma of

tertiary syphilis. Rare entities to be included in the differential diagnosis are defects of thyroglossal duct origin or branchial cleft, salivary gland and duct fistula and suppurative lymphadenitis (Kansal et al., 2013; Patni et al., 2010). Pustule is the most common of all purulent draining lesions and is readily recognized by its superficial location and short course. Actinomycosis exhibits multiple draining lesions and characteristic fine yellow granules in the purulent discharge. The tooth is often not involved radiographically. If a sinus tract does not close after appropriate removal of the primary cause, the most common alternative cause is actinomycosis (Mittal and Gupta, 2004; Patni et al., 2010). Osteomyelitis of jaw is usually secondary to some type of exogenic trauma, acquired infection after extraction of diseased teeth, impacted teeth, or retained roots. It rarely gives rise to a cutaneous sinus and is mostly associated with a history of some debilitating systemic disease or fracture (Mittal and Gupta, 2004; Patni et al., 2010). Orocutaneous fistula occurs frequently after trauma to the head and neck region and leads to continual leakage of saliva or to lower face or neck. Malignancy usually presents as fixation to underlying skin with involvement of underlying osseous structures (Patni et al., 2010). A salivary gland fistula has a characteristic location and associated patient history. Moreover, the defect is not through and through as in orocutaneous fistula. Probing the duct and performing sialography aid diagnosis (Mittal and Gupta, 2004). Thyroglossal duct cyst and branchial sinus are developmental lesions and therefore are observed early in life. The former, however, is found high in midline and is stressed when the tongue protrudes, whereas the latter is found in the lateral neck region (Mittal and Gupta, 2004).

Non-surgical therapy is the treatment of choice if the tooth is restorable. Extraction is indicated for non-restorable teeth (Satish et al., 2013).

Some difference exists in the literature regarding the removal of the sinus tract itself. Winstock (1959) recommended excision of the cutaneous lesion and sinus in continuity at the time of treatment of the dental pathology with immediate plastic repair of the cutaneous site. However, most authors pointed that once the primary odontogenic cause is removed, the sinus tract and cutaneous lesion heal without further treatment. Healing occurs by secondary intention in most cases. Cosmetic surgical treatment may be required at a later date if the healing results in cutaneous retraction or dimpling (Patni et al., 2010). Nowadays, orthograde root canal treatment is favored. After elimination of the reason of the infection, the sinus tract regularly disappears within 5 to 14 days (Cantatore et al., 2002). Root canal irrigation is one of the most critical procedure and a very important factor adjudicating on the success of root canal treatment. Sodium hypochlorite was used most of the time to irrigate the root canals, because of its bactericidal effects and for dissolving residual necrotic tissue. EDTA

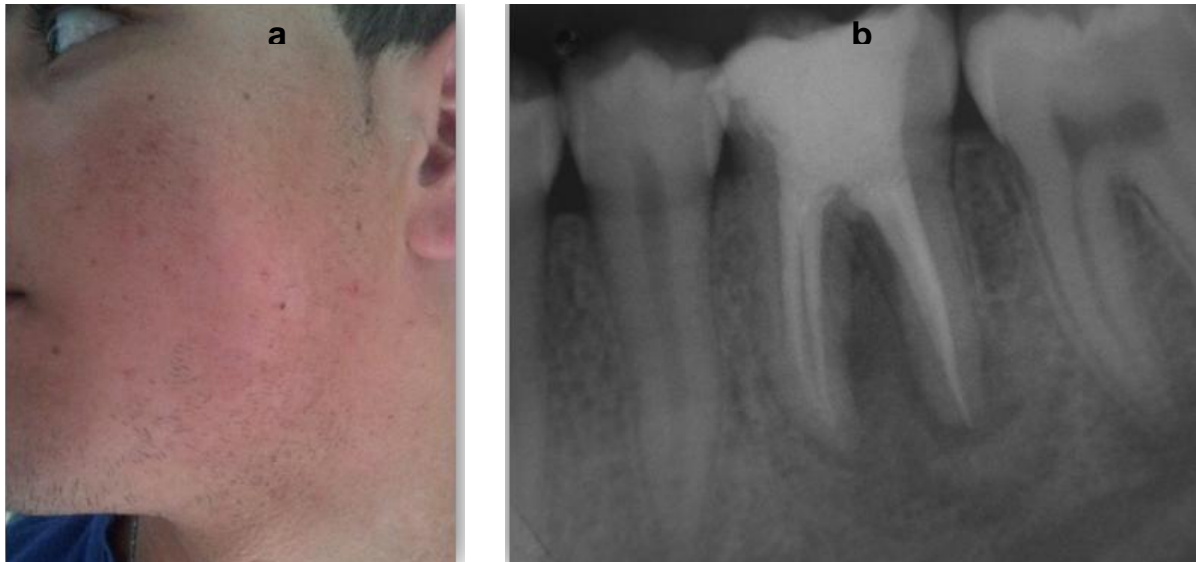


Figure 9. Six month follow-up: (a) healing of extra-oral sinus tract, (b) radiograph showing signs of peri-apical healing.



Figure 10. One year follow-up: complete resolution of the peri-apical lesion.

was used to eliminate the smear layer (Yuksel et al., 2010). Calcium hydroxide is an intra-canal medicament that is commonly used, because of its ability to predictably disinfect the root canal system. Its biological properties are achieved by the dissociation in Ca^{2+} and OH^- ions. The antimicrobial effects of calcium hydroxide relate directly to its high alkalinity (pH 12.5), it has a destructive effect on cell membranes and protein structures (Kansal et al., 2013). The use of calcium hydroxide appears to promote a favorable environment for osseous repair and the resolution of the sinus tract.

Clinical and radiographic follow-up should be regular to detect non healing cases or cutaneous retraction. In these cases, surgery should be considered.

Conclusion

A dental cause must be considered for any cutaneous sinus tract involving the face or neck. It may be concluded that the correct diagnosis is the key to treat cutaneous sinus tracts. Non-surgical treatment is the first

treatment choice that will result in predictable and rapid healing of these lesions. Surgery should only be considered in cases resisting conservative therapy.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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