RESOLUTION OF MAXILLARY SINUS MUCOSITIS AFTER ENDODONTIC TREATMENT OF MAXILLARY TEETH WITH APICAL PERIODONTITIS: A CONE-BEAM COMPUTERIZED TOMOGRAPHY PILOT STUDY

by

Babak Nurbakhsh

A thesis submitted in conformity with the requirements for the degree of Master of Science
Graduate Department of Dentistry
University of Toronto

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ABSTRACT

This study characterized maxillary sinus mucositis (SIMS) adjacent to teeth with apical periodontitis (AP), and assessed its resolution three months after endodontic treatment. 29 subjects who maxillary posterior teeth with AP were imaged with cone-beam computed tomography (CBCT). Resolution of SIMS was assessed with CBCT three months after treatment, and periapical healing was assessed using the PAI after six months. Four non-compliant subjects were discontinued and SIMS was identified in 14/25 subjects (56%). Three months post-treatment, SIMS was resolved fully in 3/10 subjects (30%), and partially in 3/10 subjects (30%). Six months post-treatment, 6/10 subjects (60%) were classified as healed or healing. CBCT revealed a lower-than-expected prevalence of SIMS adjacent to teeth with AP. In specific cases SIMS might linger beyond three months after the elimination of the endodontic infection. Due to the low statistical power, association between the resolution of SIMS and periapical healing could not be explored.
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1. GENERAL INTRODUCTION

1. Maxillary sinus

1.1 Normal development and anatomical appearance of the maxillary sinus

The maxillary sinuses are one of the four paired sets of the paranasal sinuses and the first to develop. In the second month of fetal life, an invagination forms in the lateral wall of the nasal fossa in the middle meatus (1). By the third to fourth months of fetal life, the sinus develops into a pouch and extends into the maxillary bone. At birth, it remains little more than a small sac, no more than 8 mm in length anteroposteriorly (1, 2). Over time, these air-filled pyramid-shaped cavities extend further laterally and inferiorly as the maxilla becomes more pneumatized (1, 3). When pneumatization involves the alveolar process, the cavity appears to develop around the roots of maxillary teeth (1).

The maxillary sinus continues to grow until eruption of the permanent teeth (4). The adult sinus is variable in its extension, in one-half of cases extending into the alveolar process forming an alveolar recess. In these instances the sinus comes in close proximity to the roots of the maxillary posterior teeth. With the loss of posterior teeth, the sinus can extend further into the alveolar bone, even reaching the alveolar ridge occasionally (4).

The roof of the maxillary sinus forms the floor of the orbit and is a thin bone wall with the infraorbital neurovascular bundle in its centre. The anterior wall contacts the canine fossa of the maxilla, and the posterior wall separates the sinus from the contents of the infratemporal and pterygomaxillary fossae. The floor of the sinus is formed by the alveolar process of the maxilla and the hard palate (4).
Radiographically, the floor of the maxillary sinus appears as a thin radiopaque line (1). If there is little pneumatization of the alveolar process, the floor of the sinus may be seen superior to the roots of the maxillary posterior teeth, or it may not be visible on periapical radiographs. If the maxilla is extensively pneumatized, the floor of the sinus will appear to drape around the roots of the teeth or be superimposed over the roots of the teeth, giving the appearance of the roots penetrating the sinus floor. In these cases, the lamina dura of maxillary posterior teeth may form a portion of the sinus floor (1). Radiopaque lines within the sinus may represent folds or septa of cortical bone projecting from the floor and wall of the maxillary sinuses (5).

The maxillary sinus communicates with the nasal cavity through the ostiomeatal complex. This complex is a functional entity of the anterior ethmoid bone that is the common pathway for drainage and ventilation of not only the maxillary, but also the frontal and anterior ethmoid sinuses (6). The opening or ostium of the maxillary sinus is found on its medial wall and is lined by mucosa that may become inflamed, blocking the drainage of fluids during disease (3). This lining of the sinus is considered a primary functional unit and is composed of ciliated pseudostratified columnar epithelium, along with goblet, basal and intermediate cells (3, 4, 7). The cilia through their movement serve to remove mucous, in the direction of the ostium (4). Goblet cells secrete mucous upon irritation, while serous and mucous glands located beneath the basement membrane produce mucous in response to the autonomic nervous system (3, 4).

The function of the maxillary sinus remains unknown (1, 4). It has been suggested that it may have no function whatsoever, being a remnant of evolutionary space (1). Theories have suggested that it serves as a reserve chamber that warms inspired air, reduces the weight of the skull, provides protection to the brain, regulates intranasal pressure, increases the surface area of
the olfactory membrane, provides absorption of shocks to the head and gives resonance to the voice (1, 3, 4).

1.2 Inflammatory diseases of the maxillary sinus

Inflammatory diseases of the maxillary sinus have diverse etiologies that may include foreign body reaction, infection, facial trauma, chemical irritation and allergies. These diseases may display changes consistent with mucositis, sinusitis, retention pseudocysts, polyps, and periostitis (1).

1.2.1 Sinus mucositis (SIMS)

The mucosal lining of the maxillary sinus is generally thin, and it cannot be visualized radiographically. Thickening of the mucosal lining, referred to as sinus mucositis (SIMS), may occur when an infectious or allergic stimulus occurs (1). Radiographically, SIMS appears as a band of non-corticated tissue overlying the bony wall of the sinus (1). Despite SIMS being an inflammatory disease, it may not necessarily produce clinical symptoms (8).

1.2.2 Sinusitis

Sinusitis is generalized inflammation of the sinus due to bacteria, allergen(s) or a virus. Ciliary function may be impaired because of this inflammation resulting in sinus secretions being retained. As well, the ostiomeatal complex may become blocked, preventing drainage (1).

Acute sinusitis may arise from viral infections manifested as the common cold and may be accompanied by pain and tenderness to pressure, or swelling over the involved sinus. Although sinusitis may cause maxillary posterior teeth on the affected side to become sensitive to
percussion, this is more common with bacterial sinusitis where a greenish yellow discharge may result. In such cases, the teeth must be ruled out as a source of pain or infection (1, 9).

Chronic maxillary sinusitis develops from an acute sinusitis that does not resolve within 3 months (1). No external signs are typically displayed. While chronic sinusitis can be associated with allergic rhinitis, asthma, cystic fibrosis and dental infections (1), it may also arise as a consequence of variant anatomical features such as a deviated nasal septum or the presence of concha bullosa, both of which may inhibit the outflow of mucous. Chronic sinusitis has been shown to cause ciliary dyskinesis as a result of a loss of differentiated epithelial cells (10). When imaged, maxillary sinusitis may be viewed as partial or complete radiopacification of the sinus (1).

1.2.3 Retention pseudocysts

The term pseudocyst refers to a cyst-like lesion with a cavity that is not lined with epithelium (1). The development of retention pseudocysts is not completely understood. It has been suggested that they occur due to blockage of secretory ducts of seromucous glands in the sinus mucosa, causing submucosal accumulation of secretions (1, 8, 9). Another theory suggests that they may arise from cystic deterioration within the inflamed sinus mucosa (1).

An association between retention pseudocysts and seasonal and temperature changes has been proposed. Pseudocysts are often an incidental finding on radiographs, and are usually located in the maxillary sinus. Radiographically they appear as well-defined, non-corticated, dome-shaped radiopaque masses with an internally homogenous appearance. They have no effect on the surrounding structures, with the sinus floor remaining intact and no evidence of SIMS (1, 9).
1.2.4 Polyps

Polyps are irregular folds of thickened mucosal membrane in a chronically inflamed sinus and may appear in an isolated area or multiple sites (1, 9). Their origin is likely multifactorial, however, most researchers agree that they develop from an inflammatory process that begins with mucosal injury at the microscopic level (9, 11). Imaging of polyps with computed tomography and magnetic resonance imaging shows marked enhancement of contrast and smooth expansion with displacement or destruction of the adjacent sinus floor (9).

1.2.5 Periostitis

Exudate from odontogenic infections can diffuse through the cancellous bone toward the cortical bone of the floor of the maxillary sinus. As a result, a mechanical elevation of the periosteal lining occurs at the sinus floor. Pluripotential osteoprogenitor cells differentiate into osteoblasts, depositing new bone along the elevated periosteum. The continued movement of exudate to the sinus floor results in the cycling of this process such that layers of new bone are deposited by the periosteum adjacent to the site of infection. Radiographically, these layers of bone display the characteristic halo-like appearance (1).

1.3 Imaging of maxillary sinuses

Imaging of the maxillary sinus has been performed using many different modalities. The most suitable technique for the examination is determined by factors pertaining to the subject, the site under investigation and the strengths and weaknesses of each imaging modality.
1.3.1 Conventional radiographs

Conventional radiography has been suggested for screening of the maxillary sinus in the presence of symptoms to detect inflammatory pathological conditions, such as SIMS and periostitis. Availability, ease of use, low radiation dose and minimal cost all contribute to the use of conventional radiography in this regard (9, 12). Conventional imaging may also direct clinicians to consider other imaging modalities (9). The superimposition of overlying structures, however, may make interpretation difficult (12).

Periapical radiographs provide detailed, yet limited, views of the floor of the maxillary sinus and the adjacent maxillary teeth. A panoramic radiograph captures aspects of both sinuses, however, their inherent lower resolution and the overlapping of anatomical structures and ghost images can make comparison of the sinuses with one another difficult (1).

Skull radiography, which includes the occipito-mental (Water’s), lateral, and submentovertex skull views, have all been used to image the maxillary sinuses and allows them to be compared to one another. The lateral skull view allows visualization of the all four pairs of paranasal sinuses, but with superimposition of each member of a pair on the other (1).

1.3.2 Computed tomography (CT) and magnetic resonance imaging (MRI)

CT and MRI have been increasingly used to evaluate the paranasal sinuses. The ability to acquire multiple sections through the sinuses in different planes allows the presence and extent of disease to be determined (1). Both CT and MRI may be used to visualize the ostiomeatal complex and the nasal cavities, displaying the consequent changes to the surrounding structures. While CT is
used primarily to observe changes to the underlying bone, MRI may be used to visualize changes in the soft tissues, including neoplasms (1, 8, 9).

CT provides superior visualization of the maxillary sinus compared to conventional radiography (1, 9, 12), allowing the detection and follow-up of sinus changes associated with infected maxillary teeth (13-18). The ability to manipulate and then view anatomic structures in multiple planes makes CT a preferred modality for imaging of the sinus (1). However, the hospital-based medical CT has important drawbacks, including a high radiation dose, relatively lengthy scanning times, and limited availability (19).

1.3.3 Cone-beam computed tomography (CBCT)

The relatively recent development of CBCT has overcome some of the limitations of hospital-based medical CT. CBCT provides the ability to manipulate and view anatomic structures in multiple planes, while offering isotropic resolution, comparatively short scanning times and low radiation dose (19, 20).

CBCT units can be classified in reference to the field of view (FOV) as large- and small-field units. The difference between the two is in not only the FOV size, but also the voxel size, which is generally smaller for the small FOV units. Such units produce higher resolution images with lower radiation doses. (19, 21, 22).

CBCT has been used to detect SIMS associated with AP of maxillary teeth, with the prevalence of 77% to 83%, compared to a prevalence of 19% to 36% detected by conventional radiographs (23, 24). To date, no CBCT study has been reported on the response of SIMS to endodontic treatment of maxillary teeth with AP.
1.3.4 Risks and limitations associated with use of CBCT

In spite of the advantages of CBCT imaging, it does present limitations. First, CBCT does not have the resolution of conventional film or digital radiographs (21, 22, 25). Noise, which is additional recorded nonlinear attenuation, contributes to image degradation (20) and reduces image quality. This along with the inherent flat panel detector-based artifacts, such as pixels that do not react to exposure and saturation, affects soft tissue contrast (20).

Like other imaging modalities, CBCT images are prone to artifacts, which may arise from the subject, the CBCT unit, and from the inherent polychromatic nature of the x-ray beam (21).

Despite the reduced radiation dose of CBCT compared to CT imaging, a single exposure by the large-volume CBCT unit used in this study (MercuRay; 6 inch field of view; 100 kV; 15 mA) equates to seven periapical radiographs (D-speed film and round collimation) and approximately 18 days of exposure due to natural sources (26, 27). The risk of developing a fatal cancer from a 6-inch FOV CBCT exposure is estimated at 0.0022% (28), compared to a risk of a stochastic effect from a full mouth series of intra-oral radiographs of 0.0011% (26). By comparison, for a medical CT as used conventionally to image the sinus, the estimated lifetime risk of death from cancer is estimated at 0.01% (29). Thus, the risk associated with CBCT is 2-fold higher than for a full mouth radiographic series, but it is 5-fold lower than for a maxillofacial CT.

2. Apical periodontitis (AP)

2.1 Development and essence of endodontic infections

Injury to the pulp tissue of the tooth can occur as a result of extensive dental caries, chemical erosion, operative procedures, trauma, or cracks that may compromise the integrity of the pulpal
chamber and/or root canal system (30). If left untreated, the inflamed pulp gradually becomes necrotic, leading to bacterial penetration apically (30).

The role of bacteria in pulpal disease was first demonstrated by Kakehashi (31). The root canal space is a selective habitat where the micro-organisms and their by-products can proliferate and advance towards the periradicular tissues (32). Eventually, this leads to an inflammatory process within the supporting tissues of a tooth, referred to as apical periodontitis (AP) (33). The presence of bacteria in periapical inflammatory reactions was demonstrated by Sundqvist (34) and Moller et al. (35). Inflammation represents the body’s host response to the infected root canal system (32). It is a dynamic process that can change spontaneously over time (30). The host defense mechanism attempts to resist and contain the infection in the periradicular tissue. The elimination of micro-organisms emerging apically and the prevention of their spread to other tissues are integral functions of this inflammatory process (36). Despite this defense reaction from the host, the established micro-organisms cannot be eliminated from the necrotic root canal system since the defense cells mediators are unable to reach this closed environment. This process can lead to the progression of AP, with different degrees of severity depending on the virulence of the infecting micro-organisms and the host defense (32).

2.2 Goals of endodontic treatment

Endodontic treatment aims to prevent or eliminate AP by eradicating or containing micro-organisms (33). Chemomechanical debridement of the root canal space does effectively reduce bacteria (37-39). Reduction to levels not detected by culturing techniques has been associated with better endodontic treatment outcomes (40). After the root canal space is cleaned, it is filled to prevent proliferation of surviving bacteria and to limit bacterial ingress coronally (41). The
quality of the root canal filling is an important factor in determining periapical health subsequent to treatment (42-44). Thus, all of proper diagnosis, treatment planning, knowledge of root canal anatomy, effective chemomechanical debridement, disinfection, shaping and filling of the root canal system, allow for the goals of endodontic treatment to be fulfilled (44, 45).

2.3 Assessment of healing of AP

2.3.1 Outcome measures

The method of determining healing after endodontic treatment is a focus of controversy (46). A recent review article (46) highlighted the limitations of conventional radiographs for detecting post-treatment AP.

Healing of AP is conventionally evaluated with periapical radiographs (47), which have inherent limitations associated with superimposition of anatomic structures and roots (5), and the inability to depict minor and moderate changes within the periapical tissues (5, 48-52). Being able to determine osseous healing depends on the distance from the site of infection to the cortical bone, as well as the density and thickness of the overlying cortical bone (5, 50-54). The radiographic size of the rarefying osteitis may also be influenced by the angulation of the radiographic exposure, which may result in distortion and an inability to visualize the site of infection (5, 53).

Two studies (55, 56) comparing periapical radiographs to histological results determined that even when the apical area was intact radiographically, 33% to 47% of cases were histologically inflamed. Furthermore, periapical radiographs have been shown to have a lower AP-detecting sensitivity than CBCT when histology (57, 58) and artificial defects prepared in human (59) and pig jaws (60) were used as the standard.
2.3.2 Follow-up period

Endodontic treatment of teeth with AP is expected to result in over 80% complete periapical bone healing (40, 47, 61-63), but the healing process is slow. Orstavik (64) described the peak of healing to be within the first year after treatment. Of the teeth that underwent apical healing of the bone, about half were healed 1 year after treatment, less than 90% were healed after 4 years, and about 95% were healed at 6 years. The remaining approximate 5% require an even longer period to appear completely healed (64-68). These results suggest that studies with shorter follow-up periods might result in the observation of more teeth with incomplete healing of the apical bone, and this could be interpreted as persistent disease. Frequently, the lengthy period required for follow-up is an obstacle to definitive restoration of the treated teeth, which may be of particular concern when these teeth are to support extensive prosthetic devices. Clinicians and patients in these situations require indications of healing being in progress, but such indicators may only be observed after considerable time. Consequently, the first assessment of healing is commonly performed six months after treatment, with the understanding that teeth may or may not show osseous healing.

2.4 Endodontic application of CT and CBCT imaging

Tachibana & Matsumo (69) were among the first to describe the applications of CT in endodontics. CBCT was adapted for dental use in 1999 (70) and as described earlier (Section 1.3.3), its arrival provided advantages over CT imaging (19, 20).

In endodontics, CBCT can aid in diagnosis and treatment planning (19, 21, 71), particularly for dento-alveolar trauma (72) and endodontic surgery (73). Since CBCT imaging enables for accurate hard tissue measurements (74) and it can identify the locations of vital anatomic
structures, such as the mandibular canal, mental foramen and maxillary sinus (19, 24, 75-79). Moreover, the position of roots can be determined, as well as the distance from the cortical and cancellous bone to root apices (75, 80, 81).

CBCT, particularly the small FOV units, also can provide crucial information on canal morphology (19, 24, 82-91), and to identify root fractures (19, 72, 92-94) and various resorptive defects (19, 95-99). Additionally, CBCT has been suggested as a diagnostic tool for identification of perforations (100) and apicomarginal communication (24), the determination of root curvature (101), and management of anomalous teeth (102, 103).

2.5 CBCT for identification of cysts versus granulomas

Differentiating of cysts from granulomas may influence the decision-making process in endodontic retreatment cases, when considering a nonsurgical or surgical approach. Cysts have been categorized as true cysts when their cavities are completely lined by an epithelial lining, or as bay or pocket cysts when the epithelially-lined cavities are open to the root canals (104, 105).

The prevalence of cysts has been reported to range from 15% to 45% (104-107). The specific healing rates of granulomas and cysts are unclear, as the histological status of teeth is unknown at the time root canal treatment. Based on the reported prevalence of cysts (15% to 45%) and healing rate of AP (over 80%) (47) it is conceivable that some cysts will heal after endodontic treatment. It has been reported that bay cysts are more likely to heal following endodontic treatment while true cysts may persist (104), precluding healing after non-surgical endodontic treatment (104, 105). Thus, a noninvasive technique that may provide additional diagnostic insight to treatment planning would be beneficial.
Trope (108) was the first to describe the use of three-dimensional imaging with medical CT to
differentiate radicular cysts from granulomas. Simon (109) used CBCT to examine seventeen
cases of extensive AP that subsequently underwent surgery. A biopsy report was obtained to
determine a diagnosis of granuloma or cyst, and 76% (13 /17) of cases coincided in diagnosis.
The remaining 24% (4/17) of cases were identified as cysts with CBCT, but as granulomas on
histopathology. It was concluded that CBCT was accurate in differentiating between cysts and
granulomas, and invasive surgery would not be required for diagnosis (109). Aggarwal (110)
found that the diagnosis with CT examination of twelve periapical lesions agreed with
histological diagnosis. More recently, Rosenberg (111) found CBCT was not as reliable as
biopsy and histological examination in differentiating between radicular cysts and granulomas.
The difference in results between this study and the previous ones (108-110) may be attributed to
variability in histological analysis or quality of the biopsy sample. Nevertheless, it appears as
though additional diagnostic information can be obtained from CBCT imaging, potentially aiding
in differentiating between cysts and granulomas in selected cases. Further research is required to
elucidate this aspect of CBCT use in endodontics.

2.6 CBCT and follow-up of AP

CBCT enables multi-dimensional image reformatting of teeth and their surrounding tissues,
eliminating superimposition of structures so that the true size, extent, nature and position of
periapical disease can be determined (80). Importantly, CBCT is capable of depicting subtle
changes in the periapical tissues, rendering it more sensitive in detecting AP than conventional
radiographs (24, 112-116). Thus, it has been suggested that CBCT imaging is a more accurate
method for viewing the periapical tissues for signs of healing after endodontic treatment (80). In
an animal study (114) the absence of or reduction in size of AP was observed in 57/79 roots
(72%) with periapical radiographs compared to 25/79 roots (32%) with CBCT 6 months after endodontic treatment. Another study (57) found CBCT measurements of AP to be larger in the mesiodistal plane when compared to periapical radiographs 6 months after endodontic treatment. A recent prospective cohort study (117) suggested that outcome predictors identified with CBCT and periapical radiographs might differ from one another. These early reports imply that assessment and follow-up of endodontic disease may be more accurate with CBCT imaging.

3. Relationship between the maxillary sinus and AP of maxillary posterior teeth

3.1 Prevalence of sinus changes

When AP is associated with the maxillary canines, premolars and molars, the inflammatory process can trigger a response within the maxillary sinus resulting in sinus mucositis (SIMS), periostitis and sinusitis (13-18, 23, 24, 118-124). These changes were first reported over 40 years ago based on conventional radiographic imaging of the sinus with the use of contrast media (118-121). The observations of these early studies have been corroborated using computed tomography (CT) (13-15) and cone beam computed tomography (CBCT) (23, 24).

A high prevalence of all sinus changes (71% to 88%) associated with infection of maxillary teeth, primarily the first and second molars, has been reported (14, 15, 23, 24). Specifically, SIMS was reported with a prevalence in the range of 77-83% (23, 24) and sinusitis with a prevalence of over 35% (124).

3.2 Resolution of sinus changes

While there is evidence to support periapical osseous healing following endodontic treatment of the affected teeth (47,64), there is comparatively little information on the resolution of SIMS
following elimination of the adjacent odontogenic infection. In two studies published over 40 years ago using conventional radiographic imaging with injection of contrast media, in a very small number of patients, SIMS was fully or partially resolved in 5/7 (71%) and 2/7 (29%) of patients, respectively, approximately one year after endodontic treatment of maxillary teeth (121), and completely resolved in 11/14 patients (78%) in 11 to 20 months after extraction of the infected teeth (120). Several case reports have also shown resolution of sinus changes after endodontic treatment (16-18, 122), but occasionally additional surgical interventions were required because of persistent disease (16, 122). The consequence of lingering SIMS includes a risk of chronic sinusitis and irreversible changes in the sinus mucosa (125), even when the triggering infection from the affected teeth is eliminated (9).

The available reports relating resolution of sinus changes (16-18, 122), and more specifically SIMS (120, 121) to elimination of odontogenic infections have been reported for follow-up periods of 1 year or longer. Infections affecting the oral mucosa, such as sinus tracts secondary to endodontic infections, have been shown to resolve within a few weeks after endodontic treatment or extraction of the affected teeth (126, 127). These studies suggest the resolution of SIMS secondary to AP of maxillary posterior teeth, also should resolve shortly after the triggering infection is eliminated by way of endodontic treatment.
II. OBJECTIVES AND HYPOTHESIS

1. Objectives

This study of patients with maxillary canines, premolars and molars with AP (the infected teeth) had the following objectives:

The primary objective was to establish the mean relative resolution (measured as percentage of preoperative presentation) of maxillary SIMS at 3 months after endodontic treatment of the infected teeth detected using CBCT imaging.

The secondary objective was to assess whether the relative resolution of maxillary SIMS observed at 3 months after endodontic treatment of the infected teeth, could be associated with periapical osseous healing monitored using conventional radiographs.

Specifically, the proposed study aimed to:

- Characterize the prevalence and radiographic features of SIMS as well as other maxillary sinus changes, and to relate SIMS to the distance between the sinus and teeth.

- Describe qualitatively the resolution of maxillary SIMS 3 months after treatment of the infected teeth.

- Quantify the relative resolution (reduction in thickness of the mucosa as percentage of preoperative thickness) of maxillary SIMS 3 months after treatment.

- Determine the proportion of subjects with resolved maxillary SIMS 3 months after treatment.
• Relate the resolution of maxillary SIMS at 3 months post-treatment, to signs of periapical osseous healing evident in periapical radiographs at 6 months after treatment.

2. Hypotheses

We hypothesized that:

• Preoperatively evident maxillary SIMS would partially or completely resolve in 90% of subjects 3 months after endodontic treatment of maxillary canines, premolars and molars with AP.

• Resolution of SIMS would be associated with periapical osseous healing 6 months after endodontic treatment.
Resolution of maxillary sinus mucositis after endodontic treatment of maxillary teeth with apical periodontitis: A cone-beam computerized tomography pilot study


* Discipline of Endodontics
** Disciplines of Pediatric and Preventive Dentistry
† Discipline of Oral and Maxillofacial Radiology,

Faculty of Dentistry, University of Toronto, Toronto, Ontario Canada

Address requests for reprints to: Dr. S. Friedman

Endodontics, Faculty of Dentistry, University of Toronto

124 Edward St., Toronto, Ontario M5G 1G6, Canada

e-mail address: s.friedman@utoronto.ca
Abstract

**Introduction:** Apical periodontitis (AP) is an inflammatory response that can affect the maxillary sinus. This study characterized maxillary sinus mucositis (SIMS) adjacent to teeth with AP, and assessed its resolution after endodontic treatment. **Methods:** Thirty maxillary sinuses in subjects (n=29) who had AP associated with maxillary posterior teeth were imaged with cone-beam computed tomography (CBCT). Where SIMS was detected, its resolution was assessed with CBCT 3 months after treatment, and periapical healing was assessed using the Periapical Index (PAI) after 6 months. **Results:** Excluding 5 sinuses obscured by sinusitis, SIMS was detected in 14/25 sinuses (56%). Non-significant inverse association was observed between the mucosal lining thickness and the distance from the sinus to root apices with AP. Four non-compliant subjects were discontinued. Three months post-treatment, SIMS was fully resolved in 3/10 subjects (30%), partially resolved in 3/10 subjects (30%), unchanged in 3/10 subjects (30%) and worsened in one subject (10%). Six months post-treatment, 6/10 subjects (60%) had reduced PAI scores classified as healed or healing. The subject with expanded SIMS at 3 months was not healing at 6 months. **Conclusions:** Within the limited sample of this pilot study, CBCT revealed a lower-than-expected prevalence of SIMS adjacent to teeth with AP. Fully resolved SIMS was not common 3 months after endodontic treatment, suggesting that in specific cases it might linger beyond 3 months after the elimination of the endodontic infection. Due to the low statistical power, association between the resolution of SIMS and periapical healing could not be explored.

**Keywords:** CBCT, maxillary sinus mucositis, endodontic treatment, healing
Introduction

Infection of the root canal systems of teeth results in inflammation and breakdown of the periapical alveolar bone, defined as apical periodontitis (AP), whereby the host defenses attempt to contain the infection and prevent it from spreading beyond the root of the affected tooth (1). In most instances, AP is localized to the periapical site; however, when associated with maxillary canines, premolars and molars, AP can trigger an inflammatory response within the adjacent maxillary sinus resulting in mucositis, periostitis and sinusitis (2-14).

The normal mucosal lining within the maxillary sinus is less than 1 mm in thickness, and not discernible radiographically. Sinus mucositis (SIMS) may develop in response to infectious or allergic stimuli producing a band of non-corticated mucosal tissue paralleling the bony wall of the sinus (15). A more exuberant and generalized mucosal response can be seen in sinusitis (15). In some instances, periosteal new bone formation or periostitis can develop (15). This usually develops in response to exudate from adjacent odontogenic infections diffusing through cancellous bone towards the corticated floor of the maxillary sinus (15, 16).

The diagnosis of the above conditions relies on radiographic imaging of the maxillary sinus. Imaging has been reported with conventional radiographs without (7, 17, 18) or with the use of contrast media (2, 3, 5), conventional computerized tomography (CT) (8, 11, 12, 17-19), or cone-beam computerized tomography (CBCT) (13, 14). CT provides superior visualization of the maxillary sinus compared to conventional radiographs (15, 17, 18). CT images can be manipulated and sinus structures viewed in multiple planes (15); however, CT radiation doses are high, the scanning times are lengthy and accessibility is limited (20). In contrast, CBCT offers comparatively lower radiation doses and shorter scanning times with isotropic image.
resolution (20, 21). With the use of CBCT, SIMS associated with AP was reported with prevalence of 77% to 83%, compared to a prevalence of 19% to 36% detected by conventional radiographs (13, 14).

Teeth associated with AP are routinely treated endodontically to control the infection and enable periapical healing (1). While complete osseous healing is expected in over 80% of treated teeth (22), bone regeneration progresses slowly and may require four years or longer to be completed (23, 24). As a result, early assessment of periapical healing is frequently inconclusive, requiring lengthy follow-up to ascertain the definitive outcome of treatment (24).

While there is an evidence base to support periapical healing following endodontic treatment, there is comparatively little information about the resolution of SIMS after elimination of the adjacent tooth-related infection. Using conventional radiographs, SIMS was reported to be fully or partially resolved in 5/7 (71%) and 2/7 patients (29%), respectively, approximately one year after endodontic therapy of the maxillary teeth (5), and completely resolved in 11/14 patients (78%) 11 to 20 months after extraction of the infected maxillary teeth (4). Several case reports have also shown resolution of sinus changes after endodontic therapy (6, 9, 10), occasionally with surgical intervention because of persistent disease (6, 9). None of the above reports used CBCT for assessment of SIMS resolution.

We hypothesized that AP-associated SIMS would partially or fully resolve in subjects within 3 months after endodontic treatment of maxillary teeth with AP. We also hypothesized that, if resolution of SIMS could be observed with CBCT imaging, correlation could be made with periapical healing in the longer term after treatment. The purpose of this CBCT study was to examine resolution of SIMS after endodontic therapy. Specifically, the aims were to: 1)
characterize SIMS in subjects having maxillary posterior teeth associated with AP; 2) quantify the resolution of SIMS three months after endodontic therapy of those teeth, and; 3) determine whether early resolution of SIMS could be associated with periapical osseous healing about the treated teeth.

Material and Methods

Subjects

Data from a preliminary study on three subjects who had AP associated with maxillary teeth (second premolar, first molar and second molar) was used for sample size calculation. CBCT imaging revealed the presence of SIMS in 2/3 subjects (66%), slightly lower than the previously reported range of to 77% to 83% in CBCT studies (13, 14). It was estimated that full or partial resolution of SIMS after endodontic treatment would be discernible in 90% of subjects, suggested by the previously reported resolution incidence of 78% to 100% after treatment or removal of the offending teeth in conventional radiographic studies (4, 5). Expecting 10% attrition of the study cohort, an inception cohort of 80 subjects was set as the target for recruitment, to achieve a final sample of 42 subjects for analysis with 80% power and alpha of 0.05.

Human research ethics approval was obtained from the Health Sciences Review Board of the University of Toronto (protocol # 23865). Twenty-nine subjects were recruited from patients requiring endodontic initial treatment or retreatment in maxillary premolar and molar teeth in the endodontics clinics at the Faculty of Dentistry, University of Toronto between September 1\textsuperscript{st}, 2009 and May 31\textsuperscript{st}, 2010. Enrollment was voluntary and subjects gave informed consent following detailed verbal and written descriptions of the study objectives and procedures, and the
risks and benefits associated with participation. Subject inclusion criteria included: age of 18 years or older, maxillary premolar or molar teeth scored with the Periapical Index (PAI) (25) greater than 2, periodontal probing depth of less than 5 mm, and agreement to comply with the treatment schedule. Excluded subjects had any of the following conditions: medically compromised (ASA III and above), pregnant, nursing mother, receiving antibiotic treatment for two months before time of recruitment, experienced occurrence in the past four weeks of the common cold or flu accompanied with fever, stuffiness, nasal discharge, pain and tenderness to pressure or swelling over the involved sinus (15, 26), disposed to active seasonal (pollen) or perennial (mold, dust) allergies, used nose drops, vasoconstrictive medications or cocaine, or had active asthma (27).

**Interventions**

Endodontic diagnostic and treatment procedures were provided by eight graduate endodontics students in the Graduate Endodontics clinic, except for one subject treated in the undergraduate clinic. Treatment providers established a pretreatment diagnosis following routine diagnostic, clinical and radiographic procedures. Periapical radiographs were exposed with round collimation and D-speed film at 70 kVp and 7 mA using Rinn XCP instruments (Dentsply Rinn, Elgin, IL). The images were processed in an automatic processor (Dent-X, Emsford, NY). After a diagnosis of AP was established, subjects were imaged with a Hitachi CB MercuRay (Hitachi Medical Systems, Tokyo, Japan) CBCT system. Imaging was performed at 100 kVp and 10 mA using a 6-inch field of view, asymmetrically centered over the region of interest. Subjects were enrolled only if SIMS was observed.
Endodontic treatment followed standard procedures, with 14 teeth receiving initial treatment and 16 teeth orthograde retreatment. Teeth were anesthetized, isolated, surface-decontaminated and accessed directly or after removal of coronal restorations and posts. In endodontic retreatment cases, previous root filling material was removed. Working length was established with the aid of an electronic apex locator (Root ZX II, J. Morita, Kyoto, Japan). Canals were cleaned and shaped with stainless steel hand files and engine-driven nickel titanium instruments with intermittent 2.5% NaOCl irrigation, and filled with gutta-percha and sealer (AH Plus Jet, Dentsply Caulk, Milford, DE or Pulp Canal Sealer, Sybron Dental Specialties, Orange, CA) using either vertical or lateral compaction. Access cavities were either temporized with a layer of Cavit (ESPE Dental, Seefeld, Germany) topped by glass-ionomer cement (Fuji II LC, GC Corp., Tokyo, Japan), or immediately restored with composite resin (Spectrum, Dentsply Caulk, Milford, DE) or amalgam. Subjects were then referred back to their primary dental care providers for final restoration as suggested by the treatment plan. Subjects were scheduled for 3-month follow-up CBCT imaging, and the importance of the routine 6-month follow-up examination to assess periapical osseous healing was reinforced. If an indication for antibiotics or anti-inflammatory drugs occurred during treatment, the patient’s participation was discontinued.

Follow-up

Two months after treatment, subjects were contacted by telephone and letter, invited to attend the 3-month follow-up examination and offered $50 (US) each as compensation for time out of work and travel expenses. During the examination, the subject’s medical history was updated with specific reference to the aforementioned exclusion criteria. If the subject presented with signs and symptoms (or a confirmed diagnosis) of sinusitis at the follow-up examination, the
examination was rescheduled until the sinusitis had resolved. If antibiotics or anti-inflammatory drugs became indicated post-treatment, the subject’s participation was discontinued. Eligible subjects had CBCT imaging performed as described above to monitor resolution of SIMS and were scheduled for the 6-month follow-up examination.

Five months after treatment, subjects were again contacted as before and invited to attend the 6-month follow-up examination to monitor progression of healing of the periapical osseous lesion. The principal investigator (BN) performed all the examinations. Subjects were examined clinically for signs and symptoms and periodontal support of the treated teeth, and exposed radiographically as described above.

**Outcome assessment**

Fifty archived CBCT image sets from patients imaged for other purposes, who had no AP of maxillary teeth, were used as historic controls to determine the range for normal mucosal lining thickness in the maxillary sinus. Six measurements of mucosal thickness were made for each of these image sets, three each in the coronal and sagittal planes, at the apices of the: 1) maxillary first premolar; 2) maxillary second premolar; and 3) palatal root of the maxillary first molar. The mean mucosal thickness was 1.60 ± 1.94 mm. Accordingly, mucosal lining thickness greater than 3.54 mm was considered to be a sign of SIMS. The coefficient of variation was high 1.21 (1.94/1.60).

To determine the repeatability of linear CBCT measurements, the six measurements for one image set from the controls were recorded once per week for 10 weeks. Analysis of variance (ANOVA) test was performed to determine the intraobserver reproducibility of the mean recorded for each week (28). In addition, the principal investigator was calibrated with the PAI
calibration set of 100 radiographs (25), and intraobserver reproducibility of PAI scoring was determined with Cohen's kappa statistic (29).

All preoperative and follow-up CBCT images obtained from subjects in the study were viewed at 1 mm reconstructed coronal and sagittal slices with CB Works 2.0 software (Cybermed Corp., Seoul, Korea). They were viewed in a ‘blinded’ manner by the principal investigator. An Oral and Maxillofacial Radiologist (EL) resolved any ambiguous interpretations of CBCT images.

For the study subjects, the preoperative coronal and sagittal CBCT images were used to measure (in mm) the distance between the nearest point of the sinus floor to the following landmarks: the root apex of the maxillary tooth with AP (distance RA), and the border of the AP defect (distance AD). The shortest measurement for each distance was recorded.

The CBCT images were used to measure (in mm) the greatest mucosal lining thickness adjacent to the root(s) of the affected teeth in the sagittal and coronal planes. The mean thickness was calculated for the preoperative (A) and 3-month (B) images. The primary outcome was the relative resolution of SIMS determined by the change in mucosal lining thickness, as follows: Resolution (%) = [(A-B)/A] x 100. SIMS was considered fully resolved when the mucosal lining thickness in the 3-month images was less than or equal to 3.54 mm.

The secondary outcome was the periapical osseous healing at the 6 month follow-up. All preoperative and follow-up radiographs were viewed “blinded” by the principal investigator. The presence or absence of clinical signs and symptoms and the PAI score (25) were used to define the interim outcome of treatment as follows: Healed - absence of clinical signs and symptoms and a PAI score of 1 or 2 (22). Healing - absence of clinical signs and symptoms and a PAI score
greater than 2, but lower than the preoperative score. Persistent AP - presence of signs and symptoms, or a PAI score higher than or equal to the preoperative score.

Analysis

Statistical analysis was performed using SPSS 17.0 (SPSS, Chicago, IL). Descriptive statistics were generated for mucosal lining thickness and its change over time. Pearson’s correlation test was used to explore associations between the preoperative mean mucosal lining thickness and the shortest RA and AD distances recorded.

A paired Student’s t-test was used to compare the mean mucosal lining thickness preoperatively and at 3 months. McNemar’s matched pair test was used to explore associations between the relative resolution of SIMS observed with CBCT at 3 months and reduction in PAI scores observed radiographically at 6 months. All statistical tests were two-tailed and interpreted at the 5% significance level.

Results

A high degree of repeatability in the linear CBCT measurements was achieved. Intraobserver agreement for PAI calibration was $k = 0.86$, indicating very good agreement (29).

A total of 30 maxillary teeth (4 first premolars, 6 second premolars, 15 first molars and 5 second molars) and sinuses were assessed. Preoperative changes were recorded within 24/30 sinuses (80%), with 10 sinuses displaying more than one change. SIMS was recorded in 14/30 sinuses (47%), periostitis in 16/30 sinuses (47%), and sinusitis in 5/30 sinuses (17%) (Fig. 1). The four subjects with sinusitis, one of whom had two sinuses involved, were discontinued because air-fluid levels or complete opacification within the sinuses obscured their preoperative mucosal
thicknesses. The adjusted prevalence of SIMS was 14/25 (56%). The mean mucosal lining thickness in these 14 sinuses ranged from 3.56 mm to 9.27 mm (Table 1).

Associations between the mean mucosal lining thickness in the 14 subjects and the RA and AD distances are plotted in Fig. 2. The Pearson correlation coefficients for distances RA (-0.463) and AD (-0.444) were statistically non-significant (p > 0.10). The prevalence of SIMS was higher when distances RA and AD were less than 2 mm (Table 2).

Of the fourteen subjects with SIMS, four subjects were discontinued. One had the tooth extracted because of fracture, one was prescribed anti-inflammatory and antibiotics during the follow-up period, one withdrew mid-treatment and one withdrew before the 3-month follow-up examination. The remaining 10 subjects were followed-up. The CBCT follow-up period ranged from 2.5 to 5 months (mean 3.4 months), and the periapical osseous healing follow-up period ranged from 5 to 7.5 months (mean 5.9 months).

The mean mucosal lining thickness measurements in the 10 subjects with SIMS are summarized in Table 1. Thickness reduction ranging from 41% to 89%, resulting in fully resolved SIMS (thickness ≤ 3.54 mm), was recorded in 3/10 sinuses (30%) (Fig. 3). Smaller thickness reduction ranging from 9% to 14%, suggestive of partial resolution of SIMS was recorded in 3/10 sinuses (30%). Minor changes in thickness, suggestive of little or no resolution of SIMS, were recorded in 3/10 sinuses (30%) (Fig. 4), while increased thickness by 360% was observed in one sinus (10%). The difference between the mean mucosal lining thickness preoperatively (5.77 ± 2.04 mm) and at 3 months (5.74 ± 4.50 mm) was not statistically significant (paired t-test, p = 0.983).

The PAI scores in the 10 subjects with SIMS, before treatment and at 6 months, are also summarized in Table 1. Based on the radiographic and clinical classification, a total of 43/10 of
teeth (40%) were healed, 2/10 of teeth (20%) were healing and 4/10 teeth (40%) had persistent AP. There was no significant association (McNemar test, \( p = 0.375 \)) between resolution of SIMS at 3 months and periapical osseous healing at 6 months.

**Discussion**

Although AP is regarded primarily as a localized infection, different changes have been described in the maxillary sinus adjacent to the affected teeth with a prevalence exceeding 70% (11, 12). Among these changes, SIMS was detected by CBCT in 77% to 83% of patients (13, 14). Our preliminary data supported the relatively high prevalence of SIMS in subjects with AP affecting maxillary teeth. At the time this study was undertaken, no CBCT-based evidence was available on the resolution of SIMS in response to endodontic treatment of maxillary teeth with AP.

The introduction of CBCT has overcome some of the limitations of hospital-based medical CT that is frequently used to examine the paranasal sinuses (20, 21). The main advantage of CBCT is the reduced radiation dosage compared with medical CT (20, 21). Easier access and reduced cost are additional important advantages. With these advantages in mind, CBCT was selected as an appropriate imaging modality to assess SIMS in this study. Use of a small-field CBCT would have offered an additional advantage over the full-field CBCT used in this study, in reduced radiation and cost. However, at the time this study was initiated, small-field CBCT was not available in our facility.

A final sample of 42 subjects was aimed for based on estimates of prevalence of SIMS, attrition and incidence of SIMS resolution. Although recruitment was attempted for well over 150 patients, it met with unexpected challenges as potential subjects for the study frequently did not
meet the strict inclusion criteria. Furthermore, some declined being exposed with the large-field CBCT. The achieved final sample of 10 subjects was consistent with that of the two previous studies on resolution of SIMS (4, 5).

Strict inclusion/exclusion criteria were employed to select only subjects with SIMS associated with AP of maxillary posterior teeth, while excluding periodontal disease and conditions characterized by nasal congestion or discharge as causes of SIMS. Also, subjects receiving therapies that could mask the presence of SIMS, such as antibiotics or anti-inflammatory drugs, were excluded. We also aimed to ensure that if resolution of SIMS was observed, it was due to the endodontic treatment rendered and not medication consumed by the subjects. Despite these strict criteria, the possibility remains that SIMS in some of the subjects resulted from, or lingered because of etiologies other than AP of the maxillary teeth.

In this study, SIMS was defined as the presence of a mucosal lining thickness greater than 3.54 mm. This measurement was in good agreement with the definition of sinus mucositis (greater than 4 mm thickness) used in previous studies using CT and CBCT imaging (11, 12, 14), but it showed high variance.

SIMS was observed with a prevalence of 56%, below the range of 77% to 83% reported elsewhere using CBCT imaging (13, 14). Total sinus changes, however, were observed with a prevalence of 80%, within the range of 71% to 88% reported for all sinus changes associated with infection of maxillary teeth, primarily the first and second molars (11, 12). These findings suggested that AP associated with maxillary posterior teeth might induce a reaction within the maxillary sinus. This reaction could be the result of exudate from the infection diffusing through
the cancellous bone following the path of blood vessels and lymphatics through the cortical bone of the floor of the sinus (16).

It was expected that an infection in closer proximity to the sinus would elicit more intense inflammatory changes within the sinus. However, given the smaller-than-desired sample size, the association between the intensity of the sinus mucosal response (thickness of the mucosal lining) and the distance from the sinus floor to the infected root and pathosis could not be explored with adequate power, other than observing a trend towards increased mucosal lining thickness with decreased distance from the sinus floor to the infected sites. If by extending the sample the mean distance between the sinus floor and infected sites was to remain as observed in this study (2.46 mm to root apex; 1.12 mm to border of AP defect), then a sample size of 76 and 59 subjects, respectively, would be required for analysis with 80% power and 5% level of significance. Interestingly, not in all subjects was the greatest thickness of SIMS observed at the point closest to the root apices with AP (Fig. 4).

We hypothesized that resolution of SIMS would begin shortly after endodontic treatment of the maxillary teeth with AP, as the source of infection is eliminated upon completion of endodontic treatment. Considering the evidence-based 80% prognosis for healing of AP (22), it was expected that resolution of SIMS would be seen in close to 80% of subjects already at 3 months post-treatment. In contrast, comparison of the preoperative and 3-month follow-up CBCT images revealed fully resolved SIMS (reduction to less than or equal to 3.54 mm) in 30% of the subjects, and partial resolution in an additional 30% of subjects. No discernible response was observed in another 30% of subjects, while a thickened mucosal lining was observed in one subject who also experienced persistence of AP associated with a sinus tract. These findings do not contrast, however, with those of previous studies based on conventional radiographic imaging with
injection of contrast media one year or longer after elimination of the infection source (4, 5).

Approximately one year after endodontic treatment of the infected teeth, SIMS was fully or partially resolved in 5/7 patients (71%) and 2/7 patients (29%), respectively (5), while approximately two years after extraction of the infected teeth, SIMS was completely resolved in 11/14 patients (78%) (4). The lower rate of resolution observed in the present study might be due to the short follow-up period of 3 months. If the resolution of SIMS continues in the 30% of subjects who showed only partial resolution at 3 months post-treatment, then the rate of complete resolution in the longer term may increase to 60%, closer to the rates reported previously (4, 5).

Also, the detection of SIMS using CBCT in this study was expected to be more sensitive than conventional radiography (13, 14), as used in the reference studies (4, 5). With less sensitive imaging, partially resolved SIMS may appear as fully resolved resulting in an increased incidence of reported full resolution.

We also hypothesized that resolution of SIMS would precede periapical osseous healing and, as such, it could be used as an early indicator of periapical healing at a later time. The kinetics of osseous healing after endodontic treatment of teeth with AP is very slow (30), so much so that of all healed teeth, only about half are healed by one year after treatment, less than 90% are healed at 4 years and about 95% are healed at 6 years (23, 24). Thus, obtaining insight into the prognosis of periapical healing is frequently an advantage in clinical practice, particularly when healing after endodontic treatment is a requisite for extensive restorative and prosthetic treatment plans. Our results did not support a significant association between SIMS resolution and periapical healing. This lack of correlation could be the result of a slower-than-expected resolution process of SIMS, or the possibility that SIMS might linger on even if the original
source of its triggering infection is eliminated. Certainly, also the small sample size was not conducive to establishing significant associations.

In summary, within the limitations of this pilot study, CBCT revealed a lower-than-expected prevalence of SIMS adjacent to teeth with AP. Full resolution of SIMS 3 months after endodontic treatment of those teeth was observed in 30% of the subjects, while partial resolution was observed in an additional 30%, suggesting that SIMS might linger beyond 3 months after the elimination of the endodontic infection. Further clinical investigations appear to be warranted into the relationship of maxillary teeth with AP and the maxillary sinuses, in order to assess the risk associated with AP and the possible benefits associated with its treatment. To this end, this study provided preliminary data that allow the calculation of an adequate sample for future studies.
References


Table 1: Maxillary sinus mucosal lining thickness and PAI scores in subjects with AP of maxillary teeth and SIMS detected with CBCT, before and after endodontic treatment.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Mean mucosal thickness (mm)</th>
<th>Resolution of SIMS</th>
<th>PAI score</th>
<th>Clinical signs and symptoms</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Before treatment</td>
<td>At 3 months</td>
<td>Reduction</td>
<td>Outcome</td>
<td>Before treatment</td>
</tr>
<tr>
<td>1</td>
<td>3.59</td>
<td>2.11</td>
<td>41.2%</td>
<td>Resolved</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>6.10</td>
<td>6.11</td>
<td>-0.1%</td>
<td>Unchanged</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>3.60</td>
<td>Discontinued</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>6.24</td>
<td>5.69</td>
<td>8.7%</td>
<td>Reduced</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>3.62</td>
<td>3.59</td>
<td>1.0%</td>
<td>Unchanged</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>3.56</td>
<td>16.35</td>
<td>-359.9%</td>
<td>Enlarged</td>
<td>5</td>
</tr>
<tr>
<td>7</td>
<td>7.95</td>
<td>3.03</td>
<td>62.0%</td>
<td>Resolved</td>
<td>3</td>
</tr>
<tr>
<td>8</td>
<td>8.33</td>
<td>7.17</td>
<td>13.9%</td>
<td>Reduced</td>
<td>5</td>
</tr>
<tr>
<td>9</td>
<td>9.27</td>
<td>Discontinued</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>5.44</td>
<td>0.59</td>
<td>89.1%</td>
<td>Resolved</td>
<td>4</td>
</tr>
<tr>
<td>11</td>
<td>4.14</td>
<td>3.61</td>
<td>12.8%</td>
<td>Reduced</td>
<td>4</td>
</tr>
<tr>
<td>12</td>
<td>3.56</td>
<td>Discontinued</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>8.76</td>
<td>9.15</td>
<td>-4.4%</td>
<td>Unchanged</td>
<td>3</td>
</tr>
<tr>
<td>14</td>
<td>4.65</td>
<td>Discontinued</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Shortest distances from the maxillary sinus floor to the root apices with AP (distance RA) and to the border of the AP defect (distance AD) in the study cohort and related to the prevalence of SIMS (% of sinuses within given distance).

<table>
<thead>
<tr>
<th>Distance (mm)</th>
<th>No. sinuses</th>
<th>RA No. SIMS (%)</th>
<th>No. sinuses</th>
<th>AD No. SIMS (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 – 2</td>
<td>13</td>
<td>9 (69%)</td>
<td>20</td>
<td>12 (60%)</td>
</tr>
<tr>
<td>&gt; 2</td>
<td>12</td>
<td>5 (42%)</td>
<td>5</td>
<td>2 (40%)</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
<td>14 (56%)</td>
<td>25</td>
<td>14 (56%)</td>
</tr>
</tbody>
</table>
Legends to Figures

Fig. 1: Typical sinus features observed in preoperative CBCT images of subjects with AP associated with maxillary posterior teeth. A. Normal mucosal lining, not discernable in the image. B. Sinus mucositis, with thickened mucosal lining. C. Sinusitis, with total sinus opacification. D. Periostitis, with elevation of sinus floor (sagittal view).

Fig. 2: Pearson correlation between the preoperative mean sinus mucosal lining thickness and the shortest distance from the sinus floor to: A. The root apices with AP (distance RA). B. The border of AP defect (distance AD).

Fig. 3: Resolution of SIMS 3 months after endodontic treatment, as detected in CBCT images on the sagittal plane (left images) and the coronal plane (right images). Thick mucosal lining (arrows) is clearly detected in the preoperative images (top) but not in the follow-up images (bottom).

Fig. 4: No resolution of SIMS 3 months after endodontic treatment, as detected in CBCT images on the sagittal plane (left images) and the coronal plane (right images). Thick mucosal lining (arrows) is clearly detected both in the preoperative (top) and follow-up images (bottom).
Fig. 1
Fig. 2 A.

![Graph A](image)

B.

![Graph B](image)
IV. DISCUSSION

SIMS is frequently associated with AP of maxillary teeth (77-83%) (23, 24). Moreover, lingering SIMS may result in the development of chronic sinusitis and irreversible changes in the sinus mucosa (125), even when the triggering infection from the affected teeth is eliminated (9). To date, the available evidence on the resolution of SIMS after elimination of the adjacent infection consists of only small case series and case reports (16-18, 120-122) and relies primarily on conventional radiographic imaging. Consequently, this study was undertaken to examine this relationship and to provide current evidence on its resolution using CBCT imaging.

1. Methodology

Patients were recruited from both the Graduate Endodontic and Undergraduate Clinics, at the Faculty of Dentistry, University of Toronto. The referral pattern for subjects seen in the Graduate Endodontic Clinic included those referred from the Emergency and Undergraduate Clinics at the Faculty of Dentistry and from dentists in private practice. The clinical conditions of subjects treated in the Graduate and Undergraduate Clinics resembled those seen in an endodontic specialty practice or private general practice, respectively. However, the cohort may not be representative of a broader population.

The treatment providers established a pretreatment diagnosis following diagnostic, clinical and radiographic procedures under the supervision of qualified endodontic specialists. Strict inclusion and exclusion criteria were employed in an attempt to select only subjects with SIMS associated with AP of maxillary posterior teeth, and to exclude periodontal disease and conditions characterized by nasal congestion or discharge as
causes of SIMS. Also, subjects receiving therapies that could mask the presence of SIMS, such as antibiotics or anti-inflammatory drugs, were excluded. We also aimed to ensure that if resolution of SIMS was observed, it was due to the endodontic treatment rendered and not medication consumed by the subjects. Despite these strict criteria, the possibility remains that SIMS in some of the subjects resulted from, or lingered because of etiologies other than AP of the maxillary teeth.

A final sample of 42 subjects was estimated based on the prevalence of SIMS, attrition and incidence of SIMS resolution. Although recruitment of well over 150 patients was attempted, it met with unexpected challenges as potential subjects for the study frequently did not meet the strict inclusion and exclusion criteria. As well, some declined being exposed with the large-field CBCT. As a result of the aforementioned obstacles in recruitment, the low statistical power of this study rendered it the value of a pilot study, even though the final sample of 10 subjects was consistent with that of the two previous studies on resolution of SIMS that had samples of seven (121) and 14 subjects (120).

The introduction of CBCT has overcome some of the limitations of hospital-based medical CT that is frequently used to examine the paranasal sinuses (19, 20). The main advantage of CBCT is the reduced radiation dosage compared with medical CT (19, 20), along with its easier access. With these advantages in mind, CBCT was selected as an appropriate imaging modality to assess SIMS in this study. At the time this study was initiated, small-field CBCT was not available in our facility. Use of a small-field CBCT would have offered an additional advantage over the large-field CBCT used in this study, in reduced radiation (21). The increased resolution provided by the small-field compared
to the large-field CBCT (21) would not have provided additional benefits to identifying changes to the sinus such as SIMS.

All CBCT images were analyzed at 1 mm reconstructed coronal and sagittal slices and were viewed and analyzed by CB Works 2.0 Software (Cybermed Corp, Seoul, South Korea). A 1 mm slice thickness has been identified as suitable for accurate measurement of selected landmarks (128).

As determined from the 50 archived CBCT image sets of subjects without AP of maxillary teeth, SIMS was defined as the presence of a mean mucosal lining thickness greater than 3.54 mm. This measurement was in good agreement with previous CT and CBCT studies that defined sinus mucositis as greater than 4 mm in thickness (14, 15, 24). The control measurements did display a high variance (CV = 1.21), likely due to the inclusion of retention pseudocysts. Retention pseudocysts were included as a variation of normal as their development is not completely understood (Section 1.2.3) (1).

Calibration was carried out to standardize linear measurements and for outcome assessment using PAI. The PAI scoring system (Appendix 1, Figure 1, page 63) has been validated and used in previous endodontic outcome studies (47, 64, 66, 129). It is based on a scoring system between the radiographic and histological appearance of periapical tissues (55). Once very good intra-observer agreement was obtained, preoperative periapical radiographs and follow-up radiographs were examined. The presence or absence of clinical signs and symptoms and the PAI score (130) were used to define the periapical outcome of treatment as healed, healing, or persistent AP. This outcome was dichotomized as healed/healing or persistent disease.
All preoperative CBCT and radiographic images were assessed in a blinded manner, without knowledge of the identity of the subjects or information pertaining to them. Follow-up CBCT and periapical radiographs were examined in a similar manner. The CBCT follow-up period ranged from 2.5 to 5 months (mean 3.4 months), and the periapical osseous healing follow-up period ranged from 5 to 7.5 months (mean 5.9 months). We expected both periods to be sufficient to observe the outcomes of interest, which were resolution of SIMS and osseous healing, respectively.

2. Results

SIMS was observed with a prevalence of 56% (14/25 subjects), which was below the range of 77% to 83% reported elsewhere using CBCT imaging (23, 24). Total sinus changes, however, were observed in 80% of subjects, which was within the range of 71% to 88% reported for all sinus changes associated with infection of maxillary teeth, primarily the first and second molars, using CT imaging (14, 15). These findings suggested that AP associated with maxillary posterior teeth might trigger a reaction within the maxillary sinus. This reaction could be the result of exudate from the infection diffusing through the cancellous bone following the path of blood vessels and lymphatics through the cortical bone of the floor of the sinus (4).

It was expected that an infection in closer proximity to the sinus would elicit more intense inflammatory changes within the sinus. Indeed, a trend was noted towards increased mucosal lining thickness with decreased distance from the sinus floor to the infected sites. Also, the greatest thickness of SIMS was observed at the point closest to the root apices with AP in 10/14 (71%) subjects. However, given the smaller-than-desired
sample size, the association between the intensity of the sinus mucosal response (thickness of the mucosal lining) and the distance between the sinus floor and the infected root and pathosis, could not be explored with adequate power. Based on the results obtained, we performed a power calculation, as follows: If the mean distances between the sinus floor and tooth root and AP defect were to remain as observed in this study (2.46 mm to root apex; 1.12 mm to border of AP defect), then a sample size of 76 and 59 subjects, respectively, would be required for analysis with 80% power and 5% level of significance.

We hypothesized that resolution of SIMS would begin shortly after endodontic treatment of the maxillary teeth with AP, as the source of infection would be eliminated upon completion of endodontic treatment. Considering the evidence-based 80% prognosis for healing of AP (40, 47, 61-63), it was expected that resolution of SIMS would be seen in close to 80% of subjects already at 3 months post-treatment. In contrast, comparison of the preoperative and 3-month follow-up CBCT images revealed fully resolved SIMS in 30% of the subjects, and partial resolution in an additional 30% of subjects (Appendix 1, Figure 2-5, pages 64-67).

In a previous study reporting on one year follow-up after endodontic treatment of the infected teeth, SIMS was fully or partially resolved in 5/7 patients (71%) and 2/7 patients (29%), respectively (121). In another study reporting on two year follow-up after extraction of the infected teeth, SIMS was completely resolved in 11/14 patients (78%) (120). Although a lower rate of resolution was observed in the present study with a full and partial resolution rate of 60%, our findings did not fall drastically below those of Ericson and Welander (120). The lower rate of SIMS resolution might be explained by
our detection of SIMS using CBCT, which was expected to be more sensitive than conventional radiography (23, 24) used in the reference studies (120, 121). With less sensitive imaging, SIMS may appear partially or fully resolved, resulting in an increased incidence of reported resolution. Another possible explanation for the lower resolution rate observed herein might be the short follow-up period of only 3 months. Although we hypothesized that SIMS would resolve quickly after elimination of the infection source, the possibility remains that the process of SIMS resolution is slower than expected or that suitable conditions for SIMS resolution do not present immediately after endodontic treatment but rather sometime later, when osseous healing is well underway.

When periapical status was assessed (Appendix 1, Figure 6-8, pg 68-70), all subjects who presented with a healing or healed PAI score had no clinical signs and symptoms, except one subject who was classified as healing, with a reduction in PAI score from 5 to 4. This subject presented a sinus tract, suggesting persistence of AP. The healed/healing rate of 60% (6/10) observed at 6 months was consistent with the recently reported 65% (20/31) healed/healing rate at 6 months (68).

We hypothesized that resolution of SIMS would precede periapical osseous healing and, as such, it could be used as an early indicator of periapical healing at a later time. The kinetics of osseous healing after endodontic treatment of teeth with AP is very slow (68), so much so that of all healed teeth, only about half are healed by one year after treatment, less than 90% are healed at 4 years and about 95% are healed at 6 years (64, 65). Occasionally, even longer periods of time may be required for complete healing to be observed. In a series of follow-up studies from Norway, it was determined that up to 10% of teeth that were considered as diseased in the second decade of life, healed in the third
decade after treatment (66, 67, 131, 132). Thus, obtaining insight into the prognosis of periapical healing is frequently an advantage in clinical practice, particularly when healing after endodontic treatment is a requisite for extensive restorative and prosthetic treatment plans. Our results did not support a significant association between SIMS resolution and periapical healing. In two subjects, resolution of SIMS corresponded to periapical healing, and in three other subjects, persistence or increase in SIMS was found when adjacent teeth displayed no healing periapically. The remaining 50% (5/10) of subjects showed no relationship between resolution of SIMS and periapical healing, with four displaying persistence of SIMS when periapical healing was observed at a later time. In the fifth subject, resolution of SIMS was observed, but no healing was demonstrated periapically, possibly due to the slow kinetics of osseous healing. The lack of correlation could be the result of a slower-than-expected resolution process of SIMS, or the possibility that SIMS might linger on even if the original source of its triggering infection is eliminated. Certainly, the small sample size was not conducive to establishing significant associations.
V. CONCLUSIONS

Within the limitations of this pilot study, CBCT revealed a lower-than-expected prevalence of SIMS (56%) associated with AP of maxillary teeth. Three months after endodontic treatment, full resolution of SIMS of those teeth was observed in 30% of the subjects and partial resolution in an additional 30% of subjects, suggesting a somewhat lower resolution rate than previously reported after one to two years. Thus, in the minority of cases (40%), SIMS might linger beyond 3 months after the elimination of the endodontic infection. No association was found between the resolution of SIMS at 3 months and periapical healing at 6 months.

Further clinical investigations appear to be warranted into the relationship of maxillary teeth with AP and the maxillary sinuses. To this end, this study provided preliminary data that would support the calculation of an adequate sample for future studies.
VI. REFERENCES


(34) Sundqvist G. Bacteriological studies of necrotic pulps. 1976.


(88) Blattner TC, George N, Lee CC, Kumar V, Yelton CD. Efficacy of cone-beam computed tomography as a modality to accurately identify the presence of second


VII. APPENDICES

Appendix 1. Figures

Figure 1. Periapical index (PAI) – reference radiographs, corresponding line drawings and associated PAI scores.
**Figure 2.** Resolution of SIMS 3 months after endodontic treatment, as detected in CBCT images on the sagittal (left images) and the coronal planes (right images). Thick mucosal lining (arrows) is clearly detected in the preoperative images (top) but not in the follow-up images (bottom).
Figure 3. Partial resolution of SIMS 3 months after endodontic treatment, as detected in CBCT images on the sagittal (left images) and the coronal planes (right images). Thick mucosal lining (arrows) is detected in the preoperative (top) and reduced at follow-up images (bottom).
Figure 4. No resolution of SIMS 3 months after endodontic treatment, as detected in CBCT images on the sagittal (left images) and the coronal planes (right images). Thick mucosal lining (arrows) is clearly detected both in the preoperative (top) and follow-up images (bottom).
**Figure 5.** Development of SIMS 3 months after endodontic treatment, as detected in CBCT images on the sagittal (left images) and the coronal planes (right images). Thick mucosal lining (arrows) is detected in the preoperative (top) and expanded in the follow-up images (bottom).
Figure 6. Radiographic example of a tooth classified as healed. Classification was based on a PAI score of 1 or 2 and absence of clinical signs and symptoms (top image – preoperative; bottom image – follow-up).
Figure 7. Radiographic example of a tooth classified as healing. Classification was based on PAI score greater than 2, but lower than the preoperative score and absence of clinical signs and symptoms (top image – preoperative; bottom image – follow-up).
**Figure 8.** Radiographic example of a tooth classified as persistent AP. Classification was based on a PAI score greater than or equal to the preoperative score or presence of clinical signs and symptoms. (top image – preoperative; bottom image – follow-up).
UNIVERSITY OF TORONTO
FACULTY OF DENTISTRY
POSTGRADUATE ENDODONTIC CLINIC

Informed Consent for Endodontic Therapy*

* ___ Endodontic (root canal) Treatment  ___ Endodontic Retreatment  ___ Emergency Treatment

Name: _______________ Chart # _______ Tooth _______ Date: ______________

ACKNOWLEDGEMENT OF INFORMED CONSENT

1. I hereby acknowledge that I have been presented with and understand the major treatment considerations, including the benefits and potential risks of Endodontic Therapy. I also understand that there may be other problems that occur less frequently or are less severe.

2. Dr. __________________ has discussed the Endodontic Therapy for tooth/teeth __________________ with me. I have been asked to make a choice about that treatment.

3. Dr. __________________ has presented information to aid in the decision-making process, and I have been given the opportunity to ask him/her all the questions that I may have about the proposed Endodontic Therapy, and the treatment considerations and procedures.

4. I have been informed and understand that in the event of Endodontic Therapy, the existing restoration (filling, post, core, crown, bridge) may have to be damaged or removed and subsequently may require repair or replacement. In such an event it will not be the responsibility of Dr. ______________ or the Faculty of Dentistry, University of Toronto, to repair or provide me with a replacement for that restoration.

5. I know that the practice of dentistry is not an exact science and, therefore, reputable dentists cannot guarantee results. I acknowledge that no guarantee or assurance has been made by Dr. ________________ regarding the outcome of Endodontic Therapy.

6. I have been informed and understand the scheduling of treatment sessions to perform Endodontic Therapy may have to be changed, if so judged by Dr. _______________.
CONSENT TO UNDERGO ENDODONTIC THERAPY

7. I hereby consent to the taking of diagnostic record, including radiographs, before, during and after Endodontic Therapy, to application of local anaesthesia, and to Dr. ___________ providing Endodontic Therapy for tooth/teeth ___________.

8. I hereby authorize Dr. ___________ to provide other health care providers with information regarding the treatment of tooth/teeth as deemed appropriate. I understand that once released, Dr. ___________ has no responsibility for any further release by the individual receiving this information.

CONSENT TO USE OF RECORDS

9. I hereby give permission to Dr. ___________ to take photographs in the process of examination and/or treatment, so to enhance the dental record. I further authorize the use of my record, including such photographs, for purposes of professional consultations, research, education, or publication in professional journals.

The fee for treatment in accordance with the Fee Guide is ___________.

Note: It is expected that all accounts be paid in full upon completion of Endodontic treatment.

Thank you.

SIGNATURES

Patient: _____________________; Date: _____________________

Witness: _____________________; Date: _____________________

PATIENT’S AUTHORIZED REPRESENTATIVE

10. If you are consenting to the care of another:

I have the legal authority to sign this on behalf of _____________________

Relationship to the Patient: _____________________

Patient: _____________________; Date: _____________________

Witness: _____________________; Date: _____________________
Appendix 3. Informed consent form

University of Toronto
Faculty of Dentistry
Discipline of Endodontics

Title: Post-treatment resolution of maxillary sinus mucositis associated with apical periodontitis of maxillary teeth. A cone-beam CT investigation

CONSENT FORM

Principal Investigator: Dr. Babak Nurbakhsh

Investigators: Dr. Ernest Lam, Dr. Shimon Friedman, Dr. Bettina Basrani, Dr. Gajanan V Kulkarni, Dr. Jerry Chapnik

Name of Participant: _______________________________
1. **Aim of the project**

Dentists are aware of the potential effects of oral and dental diseases on other structures in the head and neck, and elsewhere in the body. With respect to the head and neck, changes to the maxillary air sinus may occur in response to infected upper teeth. The prognosis for resolution of these changes after root canal treatment of the infected teeth has not been assessed adequately. This study will assess the presence and prognosis of resolution of changes, specifically thickening, of the mucosal lining of the sinus after root canal treatment. To assure the best diagnostic accuracy, cone-beam computed tomography (CBCT) imaging will be used as the primary assessment tool. Use of this technology may also allow for an early assessment of improvement to root canal treated teeth.

2. **Number and duration of appointments**

   **A. Pretreatment appointment**

   At this appointment, you will be examined with routine clinical and x-ray procedures by a dentist. A preoperative CBCT will also be performed.

   **B. Root canal treatment**

   You will receive routine root canal treatment procedures for the infected upper tooth. The number of visits may vary depending on the complexity of your tooth’s anatomy and clinical presentation.

   **C. Follow-up appointments**

   1. **3 month follow-up**

   Three months after treatment, you will be contacted by letter and telephone, and invited to attend the follow-up examination. At the examination, CBCT imaging will be performed. Also at this time, you will be scheduled for the routine 6-month follow-up examination.

   2. **6 month follow-up**

   Six months after treatment, you will again be contacted by letter and telephone and invited to attend the routine follow-up examination. A routine clinical and x-ray examination will be performed. If your 3-month CBCT does not show the sinus changes to be subsiding, you will be given the option to have a repeat CBCT performed at this time, to re-assess resolution of sinus changes. This second scan will be strictly voluntary.

3. **Financial compensation**

You will be offered $60 (CDN) as compensation for time out of work and travel expenses for attending the 3-month follow-up examination.
4. Treatment provided and costs

A cost estimate of the root canal treatment will be provided by the dentist at the pretreatment appointment.

There will be no additional costs for follow-up appointments and CBCT scans.

5. Risks

The risks associated with the routine root canal treatment will be discussed at the pretreatment appointment.

The radiation exposure for one CBCT scan is equivalent to 18 days of exposure due to natural sources, or to 7 routine dental x-rays. It is much lower than a medical CT scan.

6. Expected advantages for you

In this study, we shall examine your maxillary air sinus and adjacent infected tooth. By assessing changes to the sinus with CBCT, we shall be able to assess 3-dimensionally resolution of sinus changes after root canal treatment of the infected tooth. After 3 months (a relatively short follow-up period) you will be informed of healing of your sinus, and of that of the infected tooth.

7. Confidentiality

Your participation in this study is entirely voluntary and any information that is gathered will be confidential. Your name will be coded to a number, and this coding, along with the consent forms you sign will be locked in a filing cabinet. These same precautions will be vigorously followed when the results of the study are submitted to scientific journals or during clinical and scientific presentations.

8. Questions, comments and complaints

A. Regarding endodontic treatment

Contact information will be provided at the time of the pretreatment appointment.

B. Regarding your participation

Please contact Dr. Babak Nurbakhsh at 416-979-4900 (press 6), mailbox 3023.

C. Regarding ethics

Please contact the Office of Research Ethics at ethics.review@utoronto.ca or 416-946-3273.
9. Voluntary participation

Your participation in this clinical study is entirely voluntary. You are welcome to withdraw from the study at any time without risk of penalty. There are potential risks, however, associated with withdrawal during treatment (see item 10).

10. Risks resulting from withdrawal during treatment

There are potential risks associated with withdrawal during root canal treatment. An infection may persist and worsen, and this could lead, potentially, to systemic problems.

11. Right to be informed

You will be given a copy of this signed consent form.

12. Consent declaration

I have read the consent letter outlining the terms under which I am participating in the above study, and I have had my questions answered. I understand the purpose and procedures of this study.

I have completed the enclosed medical questionnaire and I will inform the researchers involved with this project of any change in my medical health that may arise during my participation.

13. Signatures

Signature of Patient: _______________________________ Date: _________

Signature of Witness: _______________________________ Date: _________
Appendix 4. Medical history form

UNIVERSITY OF TORONTO
FACULTY OF DENTISTRY, DISCIPLINE OF ENDODONTICS

MEDICAL QUESTIONNAIRE
FOR CLINICAL STUDY ON:

Title: Post-treatment of maxillary sinus mucositis associated with apical periodontitis of maxillary teeth, a cone-beam CT investigation

To provide the best possible care for our patients, all patients are asked to fill out this questionnaire. Please answer the following questions as accurately as possible. If you have any questions or doubts, please check (✓) the “Not sure/Maybe” choice.

<table>
<thead>
<tr>
<th>1. Are you being treated for any medical condition at present or have you been treated within the past year? If so, why?</th>
<th>Yes</th>
<th>No</th>
<th>Not sure/Maybe</th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Was your last medical check-up within the past year?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Have you had an occurrence of the common cold or flu in the past 4 weeks? IF YES, was it accompanied with any of the following? Please check off (✓) all that apply.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>___ stuffiness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>___ nasal discharge</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>___ pain and tenderness to pressure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>___ swelling over the involved sinus</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>4. Has there been any change in your general health in the past year?</td>
<td></td>
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</tr>
<tr>
<td>5. Are you taking any medications or non-prescription drugs of any kind? IF YES, LIST</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Do you have any allergies? e.g. seasonal (i.e. pollen), perennial (i.e. mold, dust)</td>
<td></td>
<td></td>
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<tr>
<td>7. Have you ever had peculiar or adverse reaction to any medicines or injections? (e.g. penicillin, aspirin, local anaesthetics, “dental freezing”)</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>8. Have you ever had rheumatic fever?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Do you have or have you ever had: a) any heart or blood pressure problem?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) heart murmur or mitral valve problem?</td>
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<tr>
<td>c) hepatitis, jaundice or liver disease?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Do you have any condition that could affect your immune system, e.g. leukemia, AIDS, HIV infection?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Do you have any tendency to bruise easily or bleed for a prolonged period of time after a cut?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Have you ever been hospitalized for any illnesses or operations?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
13. Do you have, or have you ever had, any of the following? Please check off (√) all that apply.

- chest pain
- lung disease
- steroid therapy
- arthritis
- heart attack
- tuberculosis
- diabetes
- seizures
- stroke
- asthma
- stomach ulcers
- kidney disease
- diet pill therapy
- bone strengthening medication (Fosamax, Actonol)
- Parkinson’s disease

NONE OF THE ABOVE ☐

14. Are there any conditions or diseases not listed above that you have or have had in the past?

………………………………………………………………………………………

If so, what? ________________________________________________________

15. Are there any diseases or medical problems that run in your family? (e.g. diabetes, cancer or heart disease?)

………………………………………………………………………………………

16. Do you or did you smoke in the past? If so, how much? ______________

17. Do you drink alcoholic beverages on a regular basis?

………………………………………………………………………………………

18. Do you use recreational drugs (such as cocaine or amphetamines)?

19. Are you nervous during dental treatment?

20. How nervous are you? (Indicate by circling a number on the scale below).

NOT AT ALL – 1 – 2 – 3 – 4 – 5 – VERY ANXIOUS

21. If you are nervous, would you like us to consider additional techniques, along with “freezing” to help you?

………………………………………………………………………………………

22. Have you ever had any serious trouble with any previous dental treatment?..

23. For women only, are you pregnant? If so what is the expected delivery date?

I ACKNOWLEDGE that the information given above is true to the best of my knowledge and that the questions have been reviewed with me. Should there be any change to my present health status in the future, I will advise the Faculty. I have been informed that my physician may be contacted by letter or telephone in order to complete details of my medical history. I hereby consent to my physician providing the Faculty of Dentistry, University of Toronto with any information in this regard, which may help ensure safe dental treatment. Finally, I hereby acknowledge that dental treatment may be delayed until all medical information required by the Faculty of Dentistry is received.

Patient Signature: ______________________ Witness Signature: ______________________ Date: _______

Medical Doctor’s Name: ______________________ Medical Doctor’s Phone #: ______________________

Medical Doctor’s Address: ___________________________________________________________________

Specialist Doctor’s Name: ______________________ Specialist Doctor’s Phone #: ______________________

Specialist Doctor’s Address: ___________________________________________________________________